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ABSTRACT

This publication was produced in response to a perceived need for a compact reference volume that permits a rapid overview of all the projects carried out by the Division of Science Resources Studies of the National Science Foundation. It was designed to furnish sufficient information on project objectives, methods, results, and references to facilitate user identification of projects for further investigation. Included are: (1) sections on the availability of publications; (2) an overview of science and technology resources; (3) the characteristics, education, and employment of human resources; (4) financial resources from the government, industry, and higher education; (5) outputs and impacts; and (6) international science and technology. Appendices include "Principal Investigators"; "Intramural Publications, 1977-87"; and "Extramural Publications, 1977-87." This document provides a summary of 67 projects in the United States and abroad. (CW)

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# PROJECT SUMMARIES: FY 1987

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DIVISION of SCIENCE
RESOURCES STUDIES

# PROJECT SUMMARIES: FY 1987

Directorate for
Scientific, Technological,
and International Affairs
National Science Foundation

Washington, D.C. 20550
NSF 87-315

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**Suggested Citation**

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# foreword

The Division of Science Resources Studies (SRS) engages in numerous activities to produce information and analyses pertinent to a fuller understanding of the magnitude, characteristics, and dynamics of the technical resources of the United States and of the other large, industralized nations that perform research and development. Projects that produce this information either are staffed intramurally or consist of extramural activities supported through grants and contracts. The information generated is intended to be of interest to policymakers in all sectors of the national science and technology enterprise as well as to those who analyze the operation of this technical system. A need has been expressed for a compact reference volume that permits a rapid overview of all of the projects carried out by the Division and that provides a summary of each endeavor. This publication responds to such a need and is the seventh volume of an annual series. It presents an overview of the many facets that are being illuminated by SRS efforts. It also furnishes sufficient information on project objectives, methods, results, and references to facilitate user selection of projects for further investigation. Any constructive criticism or comments from the user community by which the format of this publication might be improved would be greatly appreciated.

William L. Stewart, Director
Division of Science Resources Studies
Directorate for Scientific, Technological, and International Affairs

September 1987

# contents


Page

Notes ..... ix

Availability of Publications ..... xi

Section:

I. Overviews of Science and Technology Resources ..... 1
- Chemistry Profile ..... 3
- Industry Sector Report ..... 3
- International S/T Data ..... 3
- Mechanical Engineering Profile ..... 4
- Science and Engineering Indicators ..... 4
- Science and Engineering Personnel ..... 5
- S/T Data Book ..... 5
- Scientific and Technical Personnel Data System ..... 5
- Study on the Scientific and Technical Personnel Data System ..... 6
- Women and Minorities in Science and Engineering ..... 6
- U.S. S/T Resources ..... 7
- Working Group on the Scientific and Technical Personnel Data System ..... 8

II. Human Resources ..... 9

A. Characteristics ..... 9
- Doctoral Science and Engineering Population ..... 11
- Foreign Citizens in U.S. Science and Engineering ..... 11
- Immigrant Scientists and Engineers ..... 12
- New Entrants to Science and Engineering ..... 12
- Research Participation and Characteristics of S/E Faculty ..... 13

B. Education ..... 15
- Baccalaureate Origins of Science and Engineering Doctorate Recipients ..... 17
- The Doctorate Survey ..... 17
- Graduate Science and Engineering Enrollment ..... 18
- Impact of Foreign Students on U.S. Engineering Education ..... 18
- The Relation Between Education and Professional Practice in Science, Engineering, and Public Policy ..... 19
- Undergraduate Programs in Mathematics and Computer Sciences ..... 19

C. Employment ..... 21
- Demographic and Economic Determinants of Scientific Productivity ..... 23
- The Engineering Labor Market ..... 23
- Industrial Science and Engineering Personnel Resources ..... 23
- Occupational Taxonomies for Computer Specialists ..... 24
- Projected Response of the Science, Engineering, and Technical Labor Market to Defense and Nondefense Needs ..... 24
- The Qualities of Occupationally Mobile Scientists and Engineers ..... 25
- S/T Personnel Employed by the Federal Government ..... 25
- Scientists, Engineers, and Technicians in Private Industry ..... 25
- Workshop on Data Needs for Monitoring Labor-Market Conditions for Engineers ..... 26
- Workshop on the Underrepresentation and Career Differentials of Minorities in Science and Engineering ..... 26

| | | Page |
|---|---|---|
| | Workshop on the Underrepresentation and Career Differentials of Women in Science and Engineering | 27 |
| III. | Financial Resources | 29 |
| | A. Government | 29 |
| | Federal R&D Funding | 31 |
| | Federal R&D Programs by Budget Function | 31 |
| | Federal Support to the Academic and Nonprofit Sectors | 31 |
| | B. Industry | 33 |
| | Biotechnology Research and Development in Industry | 35 |
| | Estimates of Company-Funded Industrial R&D Expenditures | 35 |
| | Industrial R&D Expenditures by State and Geographic Region | 35 |
| | Impact of Foreign R&D Funding on U.S. Private R&D Spending | 36 |
| | Research and Development in Industry | 36 |
| | C. Universities and Colleges | 37 |
| | Academic Employment of Scientists and Engineers | 39 |
| | Academic-Research Instruments in Academic Settings | 39 |
| | Academic S/E Research Facilities | 39 |
| | R&D Funds in Academic Science and Engineering | 40 |
| | Science and Engineering Research Facilities at Doctorate-Granting Institutions | 40 |
| IV. | Outputs and Impacts | 43 |
| | A. Innovations and Inventions | 43 |
| | Aggregate Indicators of Technology and Technology Innovation | 45 |
| | Developing New Indicators of Input into Science and Technology | 45 |
| | An Exploration into the Quality Dimension of Patents | 46 |
| | A Sample Survey of Industrial Innovation in the United States | 46 |
| | B. Bibliometrics | 47 |
| | Measures of Innovation and Productivity in Industry | 49 |
| | Measuring the Growth of Knowledge in the Biomedical Sciences | 49 |
| | Testing a Typology of R&D Laboratories Operating in the United States | 49 |
| | C. Economic and Social Implications | 51 |
| | The Impacts of Science on Society in the United States | 53 |
| | Organizational and Strategic Factors Affecting the Distribution of Returns from Innovation and International Technology Transfer | 53 |
| | D. Other | 55 |
| | Impact of Technological Accidents on Public Attitudes Toward Science and Technology | 57 |
| | State Science Indicators | 57 |
| | A Workshop on New Indicators of University/Industry R&D Interactions | 57 |
| V. | International Science and Technology | 59 |
| | Areas of Leading-Edge Japanese Science and Technology | 61 |
| | The Development of Science and Technology Capacity in Newly Industrializing Nations | 61 |
| | Government Funding of Academic Research in Selected Countries | 62 |
| | International Comparisons of Innovation Indicators | 62 |
| | International Flow of Scientists and Engineers into the U.S. S/T System | 62 |
| | International Training of Foreign Scientists and Engineers | 63 |
| | Japanese S/T Resources | 63 |
| | Patent-Based Technology Indicators by Industry | 64 |
| | R&D Expenditures in Selected Industrialized Countries | 64 |

Page

S/T Education and Personnel in the Soviet Union ..... 64
S/T Resources of Japan ..... 65
S/T Resources of the Pacific Rim Countries ..... 65
S/T Resources of West Germany ..... 65
Scientists and Engineers in Selected Industrialized Countries ..... 66
Stock and Employment of Scientists and Engineers in Selected Countries ..... 66
U.S. and Japanese Engineers ..... 67
U.S. Participation in International Science and Engineering Projects ..... 67

Appendixes:

A. Principal Investigators ..... 71
B. Intramural Publications, 1977-87 ..... 73
C. Extramural Publications, 1977-87 ..... 79

# notes

The Division of Science Resources Studies (SRS) of the National Science Foundation (NSF) has a legislatively mandated responsiblity to collect, compile, and analyze information related to science and technology resources and the outputs and impacts of those resources. Such a broad charter requires the pursuit of numerous activities, the products of which are used by a diverse clientele, varying from governmental science and technology policymakers to institutional managers and research analysts. The clientele are interested not only in the actual results of the various surveys and studies, but also in the nature of projects that are still in progress. This compilation of summaries provides these various users with a rapid overview of all ongoing and recently completed SRS projects. A summary publication is issued annually. Its companion volume, the SRS Publications List, also is issued annually, and identifies all SRS reports published during the previous 10 (approximately) years. The most recent issue is titled *Publications List: 1977-87*, which can be obtained from the Office of the Division Director (O/DD), SRS, telephone (202) 634-4622.

All projects cited in this Project Summaries publication were either in work or completed during FY 1987 (October 1, 1986, through September 30, 1987). The summaries include information on objectives, findings, methodology, authorship, and resulting publications. Projects for which "NA" is given under "Major Findings" and "Availability" are those that are underway and for which findings are not yet available and resulting reports are not yet published. The summaries are organized in major substantive groups. Projects noted as being intramural are those carried out directly by the staff of the Division and may include information developed under SRS sponsorship by other Government agencies and by contractors. Extramural projects are those for which institutions and/or principal investigators are identified, and are supported through NSF grants and contracts. Appendix A is an alphabetical listing of all principal investigators so identified in the project summaries.

Publications are identified in the three formats used by SRS: *Highlights*, Detailed Statistical Tables—or data sets, and Reports. A *Highlights* is normally restricted to four pages and presents the essence of the analyzed data in brief statements and in graphic and tabular form. As soon as feasible after the *Highlights* has been issued, Detailed Statistical Tables are published for the reference and convenience of other analysts and researchers. From January 1986 through September 1987, Detailed Statistical Tables were produced only on diskette. As of October 1, 1987, however, SRS will resume publishing paper copies of the Tables and will continue producing them on diskette. A more complete analysis is sometimes developed and published in a final Report. When the subject is one of an ad hoc nature, the publication is identified as a Special Report. A listing of all SRS publications issued since January 1, 1977, is included as appendixes B and C of this publication.

# availability of publications

*Reports, Highlights, and Detailed Statistical Tables*—Reports and *Science Resources Studies Highlights*, and paper copies only of Detailed Statistical Tables may be obtained by telephoning O/DD, SRS, (202) 634-4622, or by writing to the following address: National Science Foundation, Division of Science Resources Studies, Office of the Division Director, 1800 G Street, N.W., Washington, D.C. 20550. Please note that Detailed Statistical Tables were not published in paper copy during the period from January 1, 1986, through September 30, 1987; they were produced only on diskette during that period and are frequently referred to as "data sets." [Please see next paragraph for availablity.] The most recent SRS Reports on *Science Indicators* and *Women and Minorities in Science and Engineering* also may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

*Data sets*—A diskette service is offered to those who wish to obtain diskettes for data resulting from the most recent surveys conducted by SRS. Data tables earlier available in the Detailed Statistical Tables series were not published in paper copy during the period January 1986 through September 1987 but are available on diskette. [As of October 1, 1987, Tables will be produced in paper copy as well as on diskette.] Each data set is released on 5 1/4" diskettes suitable for use on IBM-compatible personal computers and is provided to the user upon receipt of the correct number of blank diskettes. Many data sets contain updated data tables, technical notes, and table of contents that were formerly available in the Detailed Statistical Tables series; other data sets contain Statistical Tables that are included in the appendixes of analytical Reports. All data sets are prepared in either standard ASCII format (including a table-printing program) or in Lotus 1-2-3 (Release 1A) format, and some are available in both formats.

Data sets generated on diskette through July 1987 are as follows:

| Title | SRS No. | Format | No. of diskettes |
|---|---|---|---|
| Characteristics of Recent Science/Engineering Graduates: 1984 | 86-D1 | ASCII | 3 |
| U.S. Scientists and Engineers: 1984 | 86-D2 | ASCII | 4 |
| Characteristics of Doctoral Scientists and Engineers in the United States: 1985 | 86-D3 | Lotus | 6 |
| Academic Science/ Engineering: Scientists and Engineers, January 1985 | 86-D4 | ASCII | 4 |
| | 86-D4 | Lotus | 5 |
| Scientists, Engineers, and Technicians in Manufacturing Industries: 1983 | 86-D5 | ASCII | 2 |
| Scientists, Engineers, and Technicians in Nonmanufacturing Industries: 1984 | 86-D6 | ASCII | 2 |
| Federal Funds for Research and Development: Fiscal Years 1985, 1986, and 1987, Volume XXXV | 87-D1 | ASCII | 8 |
| | 87-D1 | Lotus | 10 |
| Federal Support to Universities, Colleges, and Selected Nonprofit Institutions: Fiscal Year 1985 | 87-D2 | ASCII | 7 |
| | 87-D2 | Lotus | 10 |
| Academic Science/ Engineering: R&D Funds, Fiscal Year 1985 | 87-D3 | ASCII | 5 |
| | 87-D3 | Lotus | 6 |
| Federal Scientists and Engineers: Fiscal Year 1985 | 87-D4 | ASCII | 4 |
| | 87-D4 | Lotus | 5 |
| Academic Science/ Engineering: Graduate Enrollment and Support, Fall 1985 | 87-D5 | ASCII | 10 |
| | 87-D5 | Lotus | 11 |
| Academic Research Equipment in the Physical and Computer Sciences and Engineering: 1982 and 1985 | 87-D6 | ASCII | 5 |
| Scientists, Engineers, and Technicians in Trade and Regulated Industries: 1985 | 87-D8 | ASCII | 2 |
| Immigrant Scientists and Engineers: 1985 | | Lotus | 1 |
| International Science and Technology Data Update: 1986 | | Lotus | 1 |

**[In Progress]**

| | | | |
|---|---|---|---|
| Research and Development in Industry: 1985. Funds, 1985; Scientists and Engineers, January 1986 | | | |
| Science and Engineering Doctorates: 1960-86 | | | |
| Immigrant Scientists and Engineers: 1986 | | Lotus | 1 |

| | | |
|---|---|---|
| Characteristics of Recent Science/Engineering Graduates: 1986 | Lotus | 3 |
| U.S. Scientists and Engineers: 1986 | Lotus | 4 |

Users may obtain data diskettes free of charge by following these procedures:

1. Place the correct number of blank (unformatted) 5 1/4" double-sided/double-density diskettes in a box suitable for return mailing.
2. For each data-diskette set desired, enclose the following information:
   a. The title of the data set, the name of the desired format—ASCII or Lotus 1-2-3, and the SRS Number; and,
   b. The name and complete return address to which the data diskettes are to be mailed.
3. Address the box as follows:
   NSF DISKETTE SERVICE
   RDS Systems, Inc.
   6110 Executive Boulevard, Suite 605
   Rockville, Maryland 20852

RDS Systems will facilitate the processing of your request by exchanging your blank diskettes for a set of diskettes that has already been prepared.

Paper or microfiche copies of the Detailed Statistical Tables may be purchased from the National Technical Information Service, Springfield, Virginia 22161.

Data sets also are available free of charge through the SRS Electronic Bulletin Board which provides up-to-date statistical data and other information on financial and human resources related to science, engineering, and technology. It contains detailed statistical tables, brief narrative reports on current studies, and announcements of reports that have recently become available to the public.

The SRS Electronic Bulletin Board is accessible without charge to anyone who has a computer equipped with communication capabilities. The telephone number is (202) 634-1764; the settings are *no* parity, *eight* data bits, and *one* stop bit. The system supports both XMODEM and KERMIT protocols; XMODEM is the default protocol. The system is capable of handling 300, 1200, or 2400 baud rate being used.

The Board is menu-driven and provides the user with instructions on use of the system and information about its structure. Brief narrative reports and announcements of available publications (BULLETINS) can be viewed while the user is logged onto the system. Statistical tables (FILES), however, must be downloaded to the user's computer for viewing. FILES are available in ASCII and/or Lotus 1-2-3 (Release 1A) format.

Extramural articles and other publications are available from the author, publisher, or journal, and some can be obtained also from the National Technical Information Service.

For information concerning the nature and availability of any of the data mentioned in this Project Summaries report, written or telephone inquiries may be made to the following appropriate offices of the Division of Science Resources Studies, 1800 G Street, N.W., Washington, D.C. 20550:

| | |
|---|---|
| Surveys and Analysis Section (SAS) | (202) 634-4691 |
| Government Studies Group | (202) 634-4636 |
| Industry Studies Group | (202) 634-4648 |
| Science and Engineering (S/E) Education Sector Studies Group | (202) 634-4787 |
| Science and Technology (S/T) Personnel Characteristics Studies Group | (202) 634-4664 |
| Universities and Colleges Studies Group | (202) 634-4673 |
| Special Analytical Studies Section (SASS) | (202) 634-4625 |
| Economic Analysis Studies Group | (202) 634-4625 |
| Employment Studies Group | (202) 634-4655 |
| International Studies Group | (202) 634-4640 |
| Science Indicators Studies Group | (202) 634-4682 |

Written or telephone inquiries concerning the availability of publications may be directed to SRS Office of the Division Director, Room L611, (202) 634-4622.

# section i. overviews of science and technology resources

## PROJECT: Chemistry Profile

**Objective:**

To provide current and historical information on personnel, education, and funding for the field of chemistry.

**Method:**

Profiles are based, in general, on information from regularly recurring SRS surveys.

**Major Findings:**

Employment of chemists reached about 195,000 in 1986. Over the 1976-86 decade, their annual employment growth rate (4%) was below average in comparison to the growth registered across all science fields (8%). The employment of women and minorities in chemistry rose at twice the annual rates for men and whites, respectively. Funding for chemistry research has risen steadily over the 1976-86 decade. For FY 1986, Federal obligations for chemistry stood at $425 million for basic research and $228 million for applied research.

**Responsible SRS Organization:**

Surveys and Analysis Section/S/T Personnel Characteristics Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Profiles—Chemistry: Human Resources and Funding*, Report, NSF 87-307, is available from SRS/Office of the Division Director.

## PROJECT: Industry Sector Report

**Objective:**

To analyze quantitative information on trends in the amount of financial and human resources invested in U.S. industrial scientific and technological activities.

**Method:**

Data on industrial R&D funding and science and engineering (S/E) personnel, primarily from various SRS surveys, were compiled, analyzed, and presented graphically.

**Major Findings:**

Industry plays a predominant role in setting current and future demand for S/E workers. In 1986, industry employed 1.1 million scientists and 2.1 million engineers, representing 54% and 80% of all personnel in these fields, respectively. Between 1976 and 1986, employment for scientists in industry increased 10% per year, and of engineers, 7% per year.

Industrial firms spend three-fourths of the funds financing research and development performed in the United States.

Companies are estimated to have used $56.7 billion of their own and $29.5 billion in Federal funds to undertake R&D activities in 1986. Total industrial R&D expenditures climbed steadily after 1975 at an average annual rate of 6% through 1986.

**Responsible SRS Organization:**

Surveys and Analysis Section/Industry Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

The final report will be published in 1988 and will be available from the SRS/Office of the Division Director.

## PROJECT: International Science and Technology Data

**Objective:**

To provide recent quantitative information annually on science and technology investments and activities in the large research and development performing industrialized nations of France, Japan, West Germany, and the United Kingdom, and to make comparisons with information on the United States.

**Method:**

In order to obtain the most current data possible, data were obtained through direct contacts with foreign organizations. Other data sources analyzed included foreign national reports and information from the Organisation of Economic Co-operation and Development.

**Major Findings:**

The United States spends more on research and development than Japan, West Germany, France, and the United Kingdom combined. Relative to the size of their economies, however, some of these countries are making similar investments in research and development; in 1986, the U.S. ratio of R&D to GNP was 2.8%, compared with 2.7% for West Germany and 2.8% for Japan in 1985. When defense research and development is excluded, these latter two countries have higher ratios of nondefense R&D to GNP—2.6% and 2.8%, respectively—compared with a U.S. ratio of 1.9% in 1986. Industry financed half of the U.S. R&D effort in 1985 compared with 67% in Japan, 61% in West Germany, and a little more than 40% in France and the United Kingdom.

The United States and the United Kingdom have almost twice the number of nonacademic scientists per 1,000 persons in the labor force than does France or Japan. Each of the countries of West Germany and Japan has 19 engineers for every 1,000 persons in the labor force—the highest ratio of all these countries. In 1985, Japan graduated 71 thousand baccalaureate engineers compared with 78 thousand in the United States. Thus, as a proportion of the college-age population, Japan is graduating twice the number of engineers than is the United States.

The United States registered a negative balance of trade in high-technology products for the first time in 1986. In 1980 the United States had a trade surplus of $26.7 billion in these products, but by 1986 the balance was a negative $2.6 billion. The U.S. high-technology trade balance with Japan has been negative for some time, and this deficit reached a high of $22 billion in 1986. The United States also registered a deficit in high-technology products of $7 billion with the newly industrialized countries of east Asia.

**Responsible SRS Organization:**

Special Analytical Studies Section/International Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*International Science and Technology Data Update: 1987*, Report, which elaborates on the foregoing findings, will be available from SRS/Office of the Division Director in late 1987. Tabular data from this report also will be obtainable on diskette and on the SRS Electronic Bulletin Board. *International Science and Technology Data Update: 1986*, Report, NSF 86-307, is available from SRS/Office of the Division Director. Tabular data from this report are obtainable on one diskette, SRS 87-D11, Lotus format, from NSF Diskette Service, in accordance with procedures specified in Availability of Publications, p. xi. Data also are available on the SRS Electronic Bulletin Board.

## PROJECT:
## Mechanical Engineering Profile

**Objective:**

To provide current and historical information on personnel, education, and funding for the field of mechanical engineering.

**Method:**

Profiles are based, in general, on information from regularly recurring SRS surveys.

**Major Findings:**

Mechanical engineers represented one-fifth (514,000) of the Nation's engineering work force in 1986. Employment in this field rose after 1976 at an annual rate of 6%, about the same as the rate for the engineering work force overall. Very few women and minorities become mechanical engineers. In 1986, women, blacks, and Hispanics represented less than 3% each of employed mechanical engineers; Asians accounted for 6%. Increases in Federal funding obligations for basic research in mechanical engineering have outpaced growth for overall engineering obligations during the 1976-86 decade.

Annual rates of increase in mechanical-engineering degree production and graduate enrollment over the last decade were greater than those reported for engineering overall.

**Responsible SRS Organization:**

Surveys and Analysis Section/S/T Personnel Characteristics Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Profiles—Mechanical Engineering: Human Resources and Funding*, Report, NSF 87-309, is available from SRS/Office of the Division Director in late 1987.

## PROJECT:
## Science and Engineering Indicators

**Objective:**

To present quantitative indicators of the state of science and technology in the United States, in order to inform national policymakers who must allocate resources to scientific and technological (S/T) activities.

**Method:**

Drafts of this biennial report are prepared in the Science Indicators Group for review by a special committee of National Science Board members. Chapters are reviewed by technical experts, by research and development executives of other Federal agencies, and by officials from the President's Office of Science and Technology Policy and the Office of Management and Budget. The completed report is issued by the full National Science Board and transmitted to the Congress by the President under a legislative mandate.

**Major Findings:**

*Science Indicators—The 1985 Report* is the seventh in a series of similar reports by the National Science Board. It presents statistical indicators with relevant interpretation and explanation. It is organized into eight chapters:

1. The International Science and Technology System
2. Support for U.S. Research and Development
3. Science and Engineering Personnel

4. Industrial Science and Technology
5. Academic Science and Engineering
6. Precollege Science and Mathematics Education
7. Public Attitudes Toward Science and Technology
8. Advances in Science and Technology

The chapter on Precollege Science and Mathematics Education was not included in the previous *Science Indicators* reports.

*Science and Engineering Indicators—1987* has been organized into nine chapters, including a summary chapter containing global and summary data. The tentative chapter titles are as follows:

1. Overview of U.S. Science and Technology
2. Precollege Science and Mathematics Education
3. Higher Education for Scientists and Engineers
4. The Science and Engineering Work Force
5. Resources for Research and Development and Basic Research
6. Academic Research and Development and Basic Research: Patterns of Performance.
7. Industrial Research and Technological Innovation
8. International Markets for U.S. Technology
9. Public Attitudes Toward Science and Technology

**Responsible SRS Organization:**

Special Analytical Studies Section/Science Indicators Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Science Indicators—The 1985 Report*, is available from the Supt. of Documents, U.S. Government Printing Office, Washington, D.C. 20402, and from the Publications Office, Room 232, National Science Foundation, 1800 G Street, N.W., Washington, D.C. 20550. *Science and Engineering Indicators—1987* will be available early in 1988.

## PROJECT:
## Science and Engineering Personnel

**Objective:**

To provide a comprehensive overview of the status of U.S. scientific and technological efforts as they relate to the employment and other characteristics of science and engineering (S/E) personnel, and to provide a perspective or framework for analyzing issues relating to these personnel.

**Method:**

Based on data from SRS surveys and other primary and secondary data sources. Report is primarily factual, with some analytical treatment of the data.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section/Employment Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

A final report is expected in early 1988 and will be available from SRS/Office of the Division Director.

## PROJECT:
## Science and Technology Data Book

**Objective:**

To present annually a graphic overview of the funding, staffing, and impacts of the Nation's scientific and technological (S/T) activities.

**Method:**

Based on data from SRS surveys and other primary and secondary data sources. Report presents information primarily by graphic means in a pocket-sized publication.

**Major Findings:**

Charts and tables provide the latest available data on the following types of science and engineering (S/E) resources: National, Federal, industrial, and academic research and development funding; supply and utilization of human resources; and international S/T indicators.

**Responsible SRS Organization:**

Special Analytical Studies Section/Economic Analysis Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Science and Technology Data Book*, 1987, Report, NSF 86-311, is available from National Technical Information Service, Springfield, Virginia 22161, PB 87-202107/AS; and from SRS/Office of the Division Director. The Data Book for 1988 will be available early in 1988.

## PROJECT:
## Scientific and Technical Personnel Data System

**Objective:**

To provide estimates of the U.S. population of scientists and engineers, as well as of their demographic, education, and employment characteristics.

**Method:**

National estimates of scientists and engineers are produced using a computer-based model that integrates data from three surveys. The Experienced Sample Survey is conducted every two years following the decennial Census and focuses on the characteristics of individuals in the science and engineering (S/E) population at the time of that Census; the Survey of Recent Science and Engineering Graduates measures the magnitude and characteristics of those who earned S/E degrees after the Census and is also conducted every two years; and the biennial Survey of Doctorate Recipients concentrates on scientists and engineers who were granted doctorates in the United States over the previous 42-year period.

**Major Findings:**

About 4.6 million scientists and engineers were employed in the United States in 1986: 2.2 million scientists (47%) and 2.4 million engineers (53%). The unemployment rate for scientists and engineers was 1.5%, substantially lower than the 7% rate for the total U.S. work force and the 2.2% rate for all professional workers. For scientists, the fastest growing employment sector was business and industry; about 54% were employed in this sector. Among engineers, business and industry continued to provide the principal source of employment (almost 75%), although academia was the fastest growing sector during the past decade. Scientists most often reported teaching, general management, and activities related to reporting, statistical work, or computing as their primary work activities, while engineers most often reported development, general management, and production/inspection activities. Women accounted for 15% of employed scientists and engineers, up from 9% ten years earlier; about 1 in 4 scientists were women as compared with 1 in 25 engineers. Black scientists and engineers increased more rapidly than other racial minority groups over the past decade: 13% per year as compared with a 7% rate for Asians and 6% per year for Hispanics. Blacks accounted for 2.5% of the S/E work force, Asians about 5%, and Hispanics about 2%.

**Responsible SRS Organization:**

Surveys and Analysis Section/S/T Personnel Characteristics Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*U.S. Scientists and Engineers: 1986*, Detailed Statistical Tables, will become available in paper copy from SRS/Office of the Division Director, on diskette, and on the SRS Electronic Bulletin Board; and in paper copy and microfiche from the National Technical Information Service early in 1988.

*U.S. Scientists and Engineers: 1984*, Detailed Statistical Tables, SRS 86-D2, set of four data diskettes in ASCII format is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Availability of Publications, p. xi. Data also are available on the SRS Electronic Bulletin Board. Paper copies @ $22.95 and microfiche @ $5.95 are available from National Technical Information Service (NTIS), Springfield, Virginia 22161, PB 86-210333/AS.

## PROJECT:
## Study on the Scientific and Technical Personnel Data System

**Objective:**

To provide advice, recommendations, and technical design specifications for the NSF Scientific and Technical Personnel Data System (STPDS) for the nineties. To review technical characteristics and performance of the STPDS during the eighties as a basis for these recommendations, including assessments of data collection methods, survey integration, as well as data quality and content.

**Method:**

A panel of 14 experts with backgrounds in statistics, survey methodology, labor economics, and science policy was selected by the National Academy of Sciences Committee on National Statistics. The panel is assembling information through briefings by NSF staff, NSF contractors, and data users and through extensive review of materials related to System/survey operation and design. Panel members are also conducting statistical studies to assess the effects of the screening algorithm used to define the science and engineering population, of survey response rates, and of various aspects of sample design.

**Major Findings:**

NA

**Responsible SRS Organization:**

Surveys and Analysis Section (SAS)

**Institution/Principal Investigator:**

National Academy of Sciences, Committee on National Statistics/Dr. Constance F. Citro

**Availability:**

The final report is expected to be available in September 1988 from the SRS Surveys and Analysis Section.

## PROJECT:
## Women and Minorities in Science and Engineering

**Objective:**

To present a factual picture of the current situation and recent trends in the participation of women and minority group mem-

bers in science and engineering (S/E) employment and training. The report is required biennially under Public Law 96-516.

**Method:**

Based on data from SRS surveys and other primary and secondary data sources. Report is primarily factual, with some analytical treatment of the data.

**Major Findings:**

Although the employment of women, blacks, and Hispanics in science and engineering increased at a more rapid rate than that of men and the majority during the 1976-86 period, they continue to be underrepresented in S/E employment. This underrepresentation reflects their low participation in precollege science and mathematics courses and in undergraduate and graduate S/E education. Asians and native Americans were not underrepresented in S/E fields in 1986.

Over the 1976-86 decade, S/E employment of women increased at a rate of 13% per year as compared with a 6% rate for men. Women accounted for 15% of the S/E work force, up from 9% in 1976. Women continue to be concentrated in certain fields; they represented 1 in 4 scientists but only 1 in 25 engineers in 1986. Among science fields, the proportion of women varied from 45% of psychologists to 12% of environmental scientists. Women are generally younger and have fewer years of professional experience than do men; almost three-fourths of the women but only one-fourth of the men had less than 10 years of experience in 1986. The unemployment rate for women was almost double that for men: 2.7% versus 1.3% for men. Annual salaries for women average 75% of those for men and were lower in all fields of science and engineering and across all levels of professional experience. Women accounted for about 45% of the bachelor's degrees granted in science fields and 15% of those in engineering. Among doctorates granted in S/E fields, women accounted for 26% in 1986.

Blacks accounted for 2.5% of employed scientists and engineers in 1986, while Asians accounted for about 5%. The unemployment rates for blacks and Asians were 3.8% and 1.8% respectively. Racial minorities report less professional experience than do the majority; almost 40% of blacks and Asians compared to 30% of whites had fewer than 10 years of professional experience. Black scientists and engineers earned lower salaries than whites, Asians, or native Americans. The average annual salary reported by blacks was $31,500; average salaries for other racial groups ranged from $41,000 for native Americans to about $39,000 for whites and Asians. Among racial groups, whites continue to score highest on the verbal component of the Scholastic Aptitude Test while Asians received the highest score on the mathematics portion. In 1985, blacks earned 5% of the S/E baccalaureates and 2% of the doctorates; the representation of Asians increased at advanced levels, rising from about 1% of the S/E baccalaureates to almost 6% of the S/E doctorates.

Hispanics represented about 2% of all employed scientists and engineers in 1986, down from 2.2% in 1984. The number of Hispanic scientists was about equal to that of Hispanic engineers, reflecting the same approximate distribution of total scientists and engineers. As with other racial minorities, Hispanics reported significantly fewer years of professional experience; almost 45% reported fewer than 10 years of experience as compared with 30% among all scientists and engineers. Annual salaries for Hispanics averaged $34,600 in 1986; for all scientists and engineers, the average was $38,400. Hispanics earned about 2.8% of S/E baccalaureates and about 2.1% of the S/E doctorates in 1985.

**Responsible SRS Organization:**

Surveys and Analysis Section/S/T Personnel Characteristics Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Women and Minorities in Science and Engineering*, Report, 1988, which elaborates on the foregoing findings, will become available from SRS/Office of the Division Director early in 1988.

*Women and Minorities in Science and Engineering*, Report, NSF 86-301, 1986, is available from SRS/Office of the Division Director, and from the National Technical Information Service, Springfield, Virginia 22161, PB 86-166360/AS, $16.95 (paper copy), $5.95 (microfiche). Appendix tables are also available on the SRS Electronic Bulletin Board.

## PROJECT:
## U.S. Science and Technology Resources

**Objective:**

To present an annual overview of U.S. science and technology resources based on the most current information available to NSF.

**Method:**

Research and development (R&D) funding information originates from a series of systematic, regularly recurring surveys of institutions. The data are then aggregated by the four major sectors of the economy—academia, government, industry, and selected nonprofit organizations—and include funding by sources of funds and performer, character of work (basic research, applied research, and development), and international comparisons.

Personnel data are derived mainly from recurring surveys of individuals. Topics concerning science and engineering (S/E) personnel include women and minorities, employment trends, S/E labor market balance, and sources of new S/E personnel.

**Major Findings:**

R&D expenditures in the United States are expected to total an estimated $125.2 billion in 1987, an increase of 7% over

the previous year (3% in constant dollars). For 1986, the overall increase in the Nation's R&D expenditures is estimated at 8% (4% in constant dollars).

S/E employment between 1976 and 1984 increased at an annual average rate of 7%, nearly three times the annual growth in total U.S. employment. As a result, the proportion of the U.S. work force engaged in S/E jobs rose from 2.6% in 1976 to 3.6% in 1984.

**Responsible SRS Organization:**

Special Analytical Studies Section/Economic Analysis Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

"Despite Continued High Level of Defense-Related R&D Spending, Growth in Nation's R&D Effort Slows," *Highlights*, NSF 87-303, March 27, 1987, available from SRS/Office of the Division Director, and *National Patterns of Science and Technology Resources: 1986*, Report, NSF 86-309, available from SRS/Office of the Division Director. Some statistical tables from the appendix of the latter publication also are available on the SRS Electronic Bulletin Board.

## PROJECT: Working Group on the Scientific and Technical Personnel Data System

**Objectives:**

To provide advice on the general design for science and engineering (S/E) personnel data collection and analysis activities for the nineties. Three major topics were addressed: (1) Identification of the strengths and weaknesses of alternative approaches to operating and maintaining the Scientific and Technical Personnel Data System (STPDS); (2) review of population concepts and occupational taxonomies; and (3) identification of both data and analyses needed to assess the demand and supply of S/E personnel.

**Method:**

Formation of the Working Group was authorized by the Advisory Committee of the Divisions of Science Resources Studies and Policy Research and Analysis. An eight-person panel, including two Advisory Committee members, was selected to be representative of the primary user communities of S/E personnel data. The Working Group held three meetings at which it heard detailed descriptions of the S/E personnel data collection activities; of the Decennial Census questions that would form the basis of S/E data collection in the nineties; and of the needs, both met and un-met, of data users. These meetings were supplemented by a two-day users' conference.

**Major Findings:**

The panel fully endorsed continued support of S/E personnel data collection and related analytic activities. General design recommendations included (1) continuation of the STPDS design as developed and implemented for the eighties; (2) increased emphasis on understanding the dynamics of the supply and demand for S/E personnel, underscoring the need for maintaining aggregate time-series as well as longitudinal data; and (3) assessing the feasibility of including secondary-school science and mathematics teachers in the STPDS. Three additional statistical studies were recommended: (1) Assessment of the NSF screening algorithm used to define the S/E population; (2) evaluation of occupational and field taxonomies; and (3) analysis of survey sampling procedures.

**Responsible SRS Organization:**

Surveys and Analysis Section

**Institution/Principal Investigator:**

[Intramural] Dr. Charlotte V. Kuh (chair)

**Availability:**

*Report and Recommendations of the Working Group on the Scientific and Technical Personnel Data System*, is available from the SRS Surveys and Analysis Section.

# section ii. human resources

## a. characteristics

## PROJECT:
## Doctoral Science and Engineering Population

**Objective:**

To obtain time-series data on employment, demographic, and other characteristics of the Nation's science and engineering (S/E) doctoral population.

**Method:**

A sample of about 57,000 S/E doctorate-holders who received their degrees during the 1942-84 period was drawn from the NSF Doctorate Records File. The survey sample was stratified by a number of variables, including field and year of degree, sex, race, and citizenship. The survey sample, about 13% of the total population, received a mail questionnaire during the spring of 1985. The estimated response rate was about 70% of those contacted. Data from the survey were used to develop national estimates.

**Major Findings:**

Employment of doctoral scientists and engineers increased from 255,000 in 1975 to 400,000 in 1985, representing an annual growth of 4.6%. The proportion of the overall S/E work force holding doctorates declined, however, from 11% to 9% over the decade. This decline was the result of faster growth of bachelor's and master's degree-recipients. In 1985, 95% of scientists and 80% of engineers were employed in a field coincident with their field of degree. Industrial employment of doctoral scientists and engineers, which grew at a greater than average rate, resulted in a pronounced relative shift in employment from academia to industry, although academia continued to be the major employment sector of doctoral scientists and engineers; 53% versus 31% in industry in 1985. In general, the proportion of doctorates citing research and develoment as their major activity remained stable, while the proportion citing teaching and management declined. Engineers, on average, reported salaries about $10,000 per year above those for scientists ($52,000 versus $42,500) in 1985. S/E doctorate-holders in industry averaged higher annual salaries than those in academia, $52,000 versus $40,000. The number of women holding doctorates in S/E fields grew at more than twice the rate of men; as a result, the proportion accounted for by women increased from 9% to 15% during the decade. S/E doctorate-holders representing racial minorities also grew at greater than average rates; Asians accounted for most of the increase.

**Responsible SRS Organization:**

Survey and Analysis Section/S/T Personnel Characteristics Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

"Employment of Ph.D. Scientists and Engineers in Industry Continues to Increase," *Highlights*, NSF 87-301, March 13, 1987, available from SRS/Office of the Division Director; *Characteristics of Doctoral Scientists and Engineers in the United States: 1985*, Detailed Statistical Tables, SRS 86-D3, set of six data diskettes in Lotus format is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Notes, p. xi. Data also are available on the SRS Electronic Bulletin Board.

*Doctoral Scientists and Engineers: A Decade of Change*, Report, will be available from SRS/Office of the Division Director in early 1988.

## PROJECT:
## Foreign Citizens in U.S. Science and Engineering

**Objective:**

To provide information on the participation of foreign citizens in U.S. higher education and in the science and engineering (S/E) labor force.

**Method:**

Data were assembled from surveys conducted by SRS and other Federal and non-Federal agencies and organizations. Data indicate trends in foreign participation and the distribution of foreign scientists and engineers by S/E field and geographic location; alternative future scenarios of foreign participation based on assumptions regarding U.S. demographic trends are provided.

**Major Findings:**

Foreign S/E enrollments in U.S. higher education at all degree levels and in all fields have nearly doubled since 1964, but still constitute less than 3% of the total. Foreign participation in S/E graduate programs has grown most rapidly, accounting for nearly one-quarter of all full-time students by 1985. In engineering, foreign students comprised over 40% of graduate enrollment and were concentrated in civil, mechanical, and electrical engineering. In full-time graduate science programs, foreign students accounted for abour 40% of the enrollments both in mathematics and in computer sciences and over 30% in the physical sciences.

The share of all science doctorates awarded to foreigners rose from 14% to 22% between 1960 and 1985; in engineering, it more than doubled, to 57%. By 1985, nearly one-half of all foreign doctorate recipients on temporary visas remained in the United States after completing their degrees. The number of foreigners holding postdoctorate appointments at U.S. universities has increased during the early eighties to about 9,000 in 1985. Nearly 3% of the S/E labor force in 1982 were foreign citizens; an additional 13% were foreign-born, naturalized U.S. citizens.

**Reponsible SRS Organization:**

Surveys and Analysis Section/S/E Education Sector Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Foreign Citizens in U.S. Science and Engineering: History, Status, and Outlook*, Report, NSF 86-305, revised, is available from SRS/Office of the Division Director.

## PROJECT: Immigrant Scientists and Engineers

**Objective:**

To provide data on the inflow of scientists and engineers to the United States under the provisions of the 1965 national immigration law.

**Method:**

NSF analyzes data that are compiled by the U.S. Immigration and Naturalization Service as part of its overall statistics program. Time-series data are available for the years since 1965. Data include field of specialization, country of birth and last residence (one year or more), age, sex, and state of intended residence, and indicate whether admission to the United States is based on worker certification by the Secretary of Labor.

**Major Findings:**

The national immigration law affects the number of immigrants admitted to the United States. Beginning in 1965, those who enter as family members are supplemented by those admitted under the "adverse effects" provisions which call for certification by the Secretary of Labor that (a) there are not enough qualified domestic workers to perform the job functions of the foreign applicant, and (b) that the proposed employment will not adversely affect the wages and working conditions of individuals similarly employed. The impact of the adverse effects provisions has been found to vary significantly. In 1969, 77% of the 13,300 immigrants received labor certification, as compared to only 28% of the 10,900 who entered in 1978. Since 1982, 46% to 56% of foreign scientists and engineers admitted to this country had been living in the United States previous to receiving immigrant status. About 20% of the immigrants admitted annually come to the United States from a country other than the country where they were born. The foregoing 1985 data have been updated to 1986; but the new data have not yet been analyzed.

**Responsible SRS Organization:**

Surveys and Analysis Section/S/T Personnel Characteristics Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Immigrant Scientists and Engineers: 1985*, Detailed Statistical Tables, SRS 87-D, one data diskette in Lotus format is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Notes, p. xi. Data also are available on the SRS Electronic Bulletin Board. Paper copies @ $9.95 and microfiche @ $6.50 are available from National Technical Information Service, Springfield, Virginia 22161, PB 87-202057/AS.

*Immigrant Scientists and Engineers: 1986*, Detailed Statistical Tables, SRS 87-D, one data diskette in Lotus format is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Availability of Publications, p. xi. Data also are available on the SRS Electronic Bulletin Board.

## PROJECT: New Entrants to Science and Engineering

**Objective:**

To obtain bienially the educational and employment characteristics of bachelor's- and master's-degree recipients in the two most recent science and engineering (S/E) graduating classes.

**Method:**

A two-stage sampling plan is utilized to obtain a sample of S/E bachelor's- and master's-degree recipients. The first stage selects a subset of institutions from the universe of higher education institutions that grant S/E degrees. The second stage samples graduates from the institutions selected in the first stage. Questionnaires were mailed to sample participants of the 1982 and 1983 S/E classes during the summer and fall of 1984, the results of which are summarized below. Questionnaires were mailed to sample participants of the 1984 and 1985 classes during the summer and fall of 1986, the results of which are in preparation.

**Major Findings:**

The average unemployment rate for all bachelor's-degree holders was 6%; for master's-degree holders, 2%. Nearly 62% of bachelor's-degree holders who were employed had S/E jobs; the comparable figure for master's-degree holders was 80%. In 1984, new graduates in mathematics, computer science, and engineering continued to experience the lowest unemployment rates (2%-4%) and highest levels of employment in S/E occupations (75%-90%). At the master's-degree level, unemployment rates were only 1%-3% with almost 95% in S/E jobs. These rates at both the bachelor's and master's levels have shown little change since 1980 despite fluctuations in economic conditions.

Continued growth in computer science job opportunities provided a high level of employment for computer science graduates as well as for graduates in other S/E fields. About 65%

of the bachelor's graduates employed as computer scientists had computer science degrees. Mathematics and engineering fields provided about three-fifths of the other graduates working in this field. Results of the 1986 survey are now being analyzed.

**Responsible SRS Organization:**

Surveys and Analysis Section/S/T Personnel Characteristics Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

"Science and Engineering (S/E) Graduates Find Increasing Opportunities for Employment in S/E Occupations," *Highlights*, NSF 85-334, February 14, 1986, available from SRS/Office of the Division Director. *Characteristics of Science/Engineering Graduates: 1984*, Detailed Statistical Tables, SRS 86-D1, set of three data diskettes in ASCII format is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Notes, p. xi. Data also are available on the SRS Electronic Bulletin Board. Paper copies @ $16.95 and microfiche @ $5.95 are available from National Technical Information Service (NTIS), Springfield, Virginia 22161, PB 86-213667/AS. *Characteristics of Recent Science/Engineering Graduates: 1986*, Detailed Statistical Tables, will become available on diskette, on the SRS Electronic Bulletin Board, and in paper copy and microfiche from NTIS early in 1988.

## PROJECT:
## Research Participation and Characteristics of Science/Engineering Faculty

**Objective:**

To provide information about characteristics and research activities of science and engineering (S/E) faculty and nonfaculty doctoral research staff in doctorate-granting institutions and to make comparisons with similar data collected in 1980.

**Method:**

In January 1986, approximately 2,000 department chairpersons in 6 engineering and 15 science fields received a questionnaire requesting information for the academic year 1985/86. The survey collected data on the number, rank, and doctoral status of full-and part-time faculty, and the tenure status, baccalaureate origins, and demographic characteristics of full-time faculty. Additional information was collected on recent faculty appointments, departures, and vacancies, the number and doctoral status of full- and part-time nonfaculty research doctorates and the research activities of faculty and nonfaculty departmental staff.

**Major Findings:**

Reversing a long-term trend, the proportion of faculty who received their doctorates within the last 7 years increased or remained constant in 11 of the 19 S/E fields surveyed in both 1980 and 1986. In the next six years, further increases are likely as a growing proportion of faculty in all fields reaches retirement age.

The 1980-86 period was one of overall growth in the number of faculty in the 19 S/E fields surveyed in both years. While the number of departments increased in many fields, the number of faculty grew even more. Therefore, average department size expanded in most of the fields, with the largest increases in the engineering fields and computer science.

Compared to 1980, faculty in 1986 were more diverse in terms of sex, race, and ethnicity. Trend data on women and minority faculty indicate that their numbers and percentages generally grew, although women composed a smaller share of faculty than they do of graduate students and recent doctorate recipients, and among minorities, only Asians constituted a larger share. Information on foreign faculty, collected for the first time in 1986, suggests that their share of assistant professorships was consistent with their representation among graduate students and recent doctorate recipients.

**Responsible SRS Organization:**

Surveys and Anslysis Section/S/E Education Sector Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

"Recent-Doctorate Faculty Increase in Engineering and Some Science Fields," *Highlights*, NSF 87-310, July 24, 1987, available from SRS/Office of the Division Director. A report will be available in fall 1987 from SRS/Office of the Division Director. Data in summary form will be obtainable on diskette early in 1988.

# section ii. human resources

## b. education

## PROJECT:
## Baccalaureate Origins of Science and Engineering Doctorate Recipients

**Objective:**

To provide a comprehensive national picture of the types of institutions that award baccalaureate degrees to persons who subsequently obtain U.S. doctorates in science and engineering. Numbers and characteristics of the doctorate recipients, characteristics and locations of baccalaureate institutions, and changes over time are presented. Detailed data on baccalaureate institutions are included for reference.

**Method:**

The study was based on data from the National Science Foundation's annual Survey of Earned Doctorates. The analysis provides information on baccalaureate origins for U.S. citizens and non-U.S. citizens with permanent visas who received doctorates from U.S. universities during the years 1983-85, with some comparisons to a similar group who had received their doctorates in 1975-77. S/E doctorates are the focus of the study, with some comparisons to non-S/E doctorates. Some summary information is also included on those doctorate recipients who were non-U.S. citizens on temporary visas. Baccalaureate institutions were classified in three ways: (1) by level of highest degree granted; (2) by research and program characteristics; and (3) by designation as a historically black institution.

**Major Findings:**

The majority of doctorate recipients received their baccalaureates from doctorate-granting institutions. Over 60% of the 1983-85 recipients of S/E doctorates received their baccalaureates from a doctorate-granting institution, approximately the same as for 1975-77 recipients. Research-intensive institutions were the baccalaureate-origin institutions for a larger proportion of the S/E doctorates than for non-S/E doctorates, 31% and 19%, respectively. Historically black colleges and universities awarded baccalaureates to 31% of the blacks who subsequently earned 1983-85 S/E doctorates, 50% of the baccalaureates to blacks earning non-S/E doctorates. There is considerable geographic mobility among those eventually receiving doctorates, from high school to baccalaureate institution and then to doctorate institution.

**Responsible SRS Organization:**

Surveys and Analysis Section/S/E Education Sector Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Baccalaureate Origins of Science and Engineering Doctorate Recipients* will be available from SRS/Office of the Division Director in early 1988.

## PROJECT:
## The Doctorate Survey

**Objective:**

To collect information on characteristics and work plans of new science and engineering (S/E) doctorates through the Survey of Earned Doctorates and to maintain the computerized Doctorate Records File, which is virtually a complete listing of about 849,000 students who have received their doctorates since 1920.

**Method:**

Individual doctorate recipients receive questionnaires that they complete near the time of graduation. In recent years, response rates have been better than 95%. Nonrespondents to the questionnaires are represented in the data base through information obtained from public records such as official commencement programs. Information is collected on demographic characteristics, educational history, sources of financial support for graduate study, and plans for postdoctoral study or employment.

**Major Findings:**

The increase in S/E doctorates from the low point in 1978 continued into 1986. The 18,770 S/E doctorates awarded in 1986 constituted 3% more than in 1985 and 10% more than in 1978, but was still less than the 19,000 peak in 1972 and 1973. The growth in 1986 reflected increases in both engineering and sciences. Engineering doctorates increased for the sixth consecutive year to 3,380, a gain of 7% over 1985. Science doctorates increased by 300 to 15,400, after a slight decline in 1985. The number of U.S. citizens receiving S/E doctorates in 1986 was down 1% from 1985, with increases in engineering insufficient to offset the continuing decreases in sciences. In contrast, non-U.S. citizens increased their awards 3% over the prior year. Foreigners accounted for 29% of all S/E doctorates awarded in the United States compared to 21% a decade earlier. Most of the non-U.S. citizens, 81% in 1986, held temporary visas.

**Responsible SRS Organization:**

Surveys and Analysis Section/S/E Education Sector Studies Group

**Institution/Principal Investigator:**

National Academy of Sciences/Susan L. Coyle

**Availability:**

"Output of Science and Engineering Doctorates Stable in 1985, But Non-U.S. Citizens and Women Increase Their Shares of the Total," *Highlights*, NSF 86-308, June 6, 1986, available from the SRS/Office of the Division Director. *Summary Report, 1985. Doctorate Recipients from United States Universities* is available from the Office of Scientific Engineering

Personnel, National Research Council, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington, D.C. 20418, and from the National Technical Information Service, Springfield, Virginia 22161. *Science and Engineering Doctorates: 1960-86*, Detailed Statistical Tables, SRS 87-D9, set of nine data diskettes in Lotus format is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Availability of Publications, p. xi. Data also are available on the SRS Electronic Bulletin Board.

## PROJECT: Graduate Science and Engineering Enrollment

**Objective:**

To provide quantitative information annually by discipline on the characteristics of graduate science and engineering (S/E) students and postdoctorates, with emphasis on their sources of support.

**Method:**

All graduate S/E departments in 325 doctorate-granting institutions and 18 master's-granting historically black colleges (HBC's), as well as a sample of 71 other master's-granting institutions, received the annual questionnaire for fall 1985 data. There were several data elements: Major sources and types of support for full-time graduate students, graduate enrollment status (full- or part-time), level of study, citizenship, sex, and racial/ethnic origin. In 1984, data were also collected on the support patterns of postdoctorates and on nonfaculty doctoral research staff.

**Major Findings:**

Graduate S/E enrollment totaled 435,000 in fall 1985, a growth of 2% over the fall 1984 total. Most of the growth is attributable to an 8% rise in the number of foreign students enrolled full time; the number of U.S. citizens fell by 1% after three successive years of slow growth. In doctorate-granting institutions, graduate engineering enrollment rose by 2%, while graduate enrollment in the sciences was virtually unchanged. In doctorate-granting institutions, slower growth in the number of women enrolled accounted for the overall slowdown in growth. All categories of outside support—research assistants, teaching assistants, etc.—showed slight increases in 1985. The number of graduate students relying primarily on self, loans, or family support declined for the second straight year.

**Responsible SRS Organization:**

Surveys and Analysis Section (SAS)/S/E Education Sector Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

"Foreign Students Fueled 2% Rise in Graduate Science and Engineering Enrollment," *Highlights*, NSF 87-306, June 12, 1987, is available from SRS/Office of the Division Director. *Academic Science/Engineering: Graduate Enrollment and Support, Fall 1985*, Detailed Statistical Tables, SRS 87-D5, set of 10 data diskettes in ASCII format, or a set of 11 data diskettes in Lotus format, is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Availability of Publications, p. xi. Data also are available on the SRS Electronic Bulletin Board. Access to the public-use tapes and documentation for their use are described in the February 1986 *Data Users Guide*, available from SAS/Universities and Colleges Studies Group. Data from the fall 1986 graduate student survey are expected to be available in fall 1987, with the *Highlights* scheduled for publication in spring 1988.

## PROJECT: Impact of Foreign Students on U.S. Engineering Education

**Objective:**

To examine the impact of foreign graduate students in four major engineering disciplines on the teaching and research programs of engineering schools, and to examine the policies that departments and schools adopt toward these students.

**Method:**

Information was collected from engineering department chairpersons and faculty members to determine the volume and type of research completed, faculty perceptions of foreign students, special problems arising from the presence of large numbers of foreign students, and financial aid provided to foreign students. Opinions as well as facts were obtained.

**Major Findings:**

Department chairpersons for U.S. graduate programs in chemical, civil, electrical, and mechanical engineering who participated in the survey reported that 47% of the master's-degree students and 53% of the doctoral students in their programs were foreign. During the previous 4 years, 87% of these departments experienced a shortage of U.S. students who had applied for full-time graduate study. Only 15% of the departments indicated that limits were imposed on the maximum percentage of non-U.S. citizens admitted for graduate study; the percentage was higher among departments rated highly in a 1982 ranking of departments conducted by the National Academy of Sciences. Shortages of faculty, reported by nearly 60% of the departments, were met in part by hiring teaching assistants, 47% of whom were foreign students. Foreign citizens were selected for 41% of full-time faculty appointments in surveyed departments; of the foreign citizens hired, 67% of them held temporary visas. Responses by engineering chairpersons and faculty indicate that foreign graduate students have assumed an important role in U.S. engineering schools, given the shortage of U.S. graduate students. While foreign students entail additional administrative work and somewhat greater

effort in teaching because of language and cultural differences, chairpersons and faculty viewed foreign graduate students, overall, as an asset.

**Responsible SRS Organization:**

Surveys and Analysis Section/S/E Education Sector Studies Group

**Institution/Principal Investigators:**

Institute of International Education/Elinor G. Barber; Washington University/Robert P. Morgan

**Availability:**

Final report is available from Elinor G. Barber, Director of Research, Institute of International Education, 809 United Nations Plaza, New York, New York 10017.

## PROJECT: The Relation Between Education and Professional Practice in Science, Engineering, and Public Policy

**Objective:**

To determine (1) if education for the emerging fields in science, engineering, and public policy (SEPP) is relevant and adequate; and (2) how this education can be made more responsive to employer requirements.

**Method:**

The project identified and surveyed SEPP departments in 21 universities, their graduates, and others employed in SEPP positions. It sought information about the relationship between course offerings and job content of workers in the SEPP fields.

**Major Findings:**

SEPP programs operate at the graduate level and are based in social science or in engineering schools and departments. Social science-based (SSB) programs differ in significant ways from engineering-based (EB) programs. EB programs seek students with undergraduate backgrounds in technical areas, and place heavier emphasis on quantitative methods in their curricula. SSB programs stress more qualitative, descriptive approaches to their subject, emphasizing case studies and an understanding of process.

There is considerable similarity in the objectives of the programs, including the conduct of interdisciplinary research and teaching on SEPP issues; enhancement of the education of scientists and engineers; enhancement of the skills of managers and policy analysts to handle science- and technology-intensive issues; and education of individuals to provide policy advice on SEPP issues. Both EB and SSB programs prepare their master's students primarily for careers in government, and their doctoral students for academic careers. More than half of the graduates of SEPP programs are employed in the SEPP field.

Graduates find their education to have been generally appropriate and useful. Those from SSB programs indicate that they could have benefited from more grounding in methodology for analytic problem-solving. Graduates of EB programs expressed the need for better understanding of the ways in which problems are treated in the actual working environment.

The report also contains data on participation in SEPP programs by sex, and on salary data for those employed in the field. The report also addresses questions of problems with program stability and recognition as a legitimate academic discipline.

**Responsible SRS Organization:**

Special Analytical Studies Section/Employment Studies Group

**Institution/Principal Investigators:**

American Association for the Advancement of Science/Albert H. Teich/Barry Gold

**Availability:**

*Graduate Education and Career Directions in Science, Engineering and Public Policy*, is available from the American Association for the Advancement of Science, Office of Public Sector Programs, 1333 H Street, N.W., Washington, D.C. 20005.

## PROJECT: Undergraduate Programs in Mathematics and Computer Sciences

**Objective:**

To provide information on undergraduate-course enrollments, faculty, and teaching patterns in mathematical and computer science departments; to examine changes in these variables over 5-year intervals since 1965; to determine the extent of remedial instruction now being offered in mathematics departments; and to identify various issues judged to be important by the departments.

**Method:**

Information was collected in fall 1985. Undergraduate programs in universities, 4-year colleges, and 2-year colleges were examined for a random sample of 2,463 institutions with undergraduate programs in the mathematical or computer sciences.

In addition to the basic questionnaire, special questions on computer sciences and on remedial instruction were included. Results are reported as national estimates, based on an overall response rate of 72% of surveyed departments.

**Major Findings:**

While overall undergraduate enrollments in universities and 4-year colleges were almost stable during 1980-85, mathematics-

course enrollments increased by 6% to 1,619,000; statistics by 41% to 208,000; and computer sciences by 74% to 558,000. Enrollments in upper-division mathematics courses were up 52% over 1980 levels, reversing a downward trend from the 1970's. The increase in full-time equivalent (FTE) faculty has not kept pace with course enrollment. After 1970, FTE faculty for all those teaching in mathematical sciences in universities and 4-year colleges increased by 6% while course enrollments in the mathematics sciences increased by 41%. In mathematical and computer sciences combined, FTE faculty grew by 40% while course enrollments grew by 72%. The percentage of doctorates among the full-time faculty has decreased from 82% in 1975 to 73% in the mathematical and computer sciences.

**Responsible SRS Organization:**

Surveys and Analysis Section/S/E Education Sector Studies Group

**Institution/Principal Investigator:**

The Mathematical Association of America/Richard D. Anderson

**Availability:**

*Undergraduate Programs in the Mathematical and Computer Sciences: The 1985-1986 Survey*, Donald J. Albers, Richard D. Anderson, and Don O. Loftsgaarden, can be obtained from Conference Board of the Mathematical Sciences, 1529 Eighteenth Street, N.W., Washington, D.C. 20036.

# section ii. human resources

## c. employment

## PROJECT:
## Demographic and Economic Determinants of Scientific Productivity

**Objective:**

To study (1) the factors determining individual scientific productivity of doctoral scientists by isolating separately the effects of age, lapse of time since degree receipt or entry into the field's labor market ("vintage"), and cumulative outside influences during the passage of time; and (2) the ramifications of these trends upon potential productivity in science fields vital to the national defense and the economy.

**Method:**

Econometric modeling is being used to sort the separate effects of age, date of degree receipt, and calendar time on productivity. The study uses pooled cross-section, time-series data from the National Research Council's 1973-79 National Survey of Doctorate Recipients. These surveys contain information on date doctorate was received, age, tenure status, race, sex, identity of doctorate-granting institution, and characteristics of the current employer. Productivity will be measured by the output of publications and will be ascertained by matching the sample population with the *Science Citation Index*.

**Major Findings:**

Preliminary analysis of the data indicates that age-publishing profiles differ substantially between sectors and between fields. Therefore, it is questionable that generalization should be made on whether science is a young person's occupation. The results also indicate that care must be taken in drawing generalizations about the scientific process from case studies that are limited in field and sector of employment. A preliminary case study of condensed-matter physics shows that effects of age are substantially diminished once vintage effects are controlled. This finding may not be applicable to other fields, however.

**Responsible SRS Organization:**

Special Analytical Studies Section (SASS)/Employment Studies Group

**Institution/Principal Investigator:**

Georgia State University/Paula Stephan

**Availability:**

Results are expected in fall 1987. For further information, contact SASS/Employment Studies Group.

## PROJECT:
## The Engineering Labor Market

**Objective:**

To provide an overview of engineering labor markets and changes that occurred in prior labor markets; to define and clarify the mechanisms used to effect changes in engineering labor markets; to identify changes in the characteristics of engineering personnel that can arise as a result of these adjustment mechanisms, to describe broadly the exogenous forces that underlie the labor market for engineers; to make inferences about market adjustments that may take place under future scenarios; to judge the impacts these adjustments might have on the quality of the engineering work force and the ability of the United States to compete internationally; and to examine the sparse data on engineering-personnel characteristics abroad.

**Method:**

The project will collect and analyze existing data and studies bearing on the issues. A panel of experts primarily from the fields of engineering and economics, with backgrounds in the areas of supply, utilization, and performance of engineers will provide guidelines and oversight to the project.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section/Employment Studies Group

**Institution/Principal Investigator:**

National Academy of Engineering and National Research Council/Alan Fechter

**Availability:**

A final report is expected in fall 1987. For information on obtaining a copy of this report, contact the National Research Council, Office of Scientific and Engineering Personnel, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

## PROJECT:
## Industrial Science and Engineering Personnel Resources

**Objective:**

To acquire and disseminate information on the industrial labor market for science and engineering (S/E) personnel to meet urgent needs of policy-level Federal officials.

**Method:**

The survey is designed to obtain qualitative and quantitative information that is not readily available on a timely basis from other sources. Six surveys were conducted between 1981 and 1985, based on an industry panel composed of company representatives from several hundred large Fortune 500 and medium-sized firms representing approximately 16% of U.S. S/E personnel. In 1986, the Panel was changed from a company- to an establishment-reporting basis. Approximately 1,200

respondents were selected to constitute a statistically valid sample designed to give NSF the capability of making national estimates of current conditions in the industrial labor market.

**Major Findings:**

Six of the surveys monitored labor-market conditions of S/E personnel from 1981 to 1986 by field, degree level, and work experience; one survey in 1985 obtained information on industry's utilization of foreign national scientists and engineers. The six labor-market surveys traced trends in the supply/demand balance of S/E personnel. In 1981, shortages were reported for chemistry and computer science, and for electrical, electronics, petroleum, and computer engineering. Shortages declined during 1982 and 1983 because of the economic recession; then in 1984, shortages increased for electrical, computer, electronics, and nuclear engineering. Between 1984 and 1986, reported labor-market balance remained generally unchanged for most fields. Shortages reported in 1986 were in the same fields. The survey on the industrial utilization of foreign S/E personnel found that significant proportions of S/E employers hired foreign personnel during the 1984-85 recruiting period.

**Responsible SRS Organization:**

Surveys and Analysis Section (SAS)/Industry Studies Group

**Institution/Principal Investigator:**

Market Facts, Inc./David Alexander

**Availability:**

*The 1985 NSF Science and Engineering Labor Market Study*, April 1986, is available from SAS/Industry Studies Group. "Survey of 300 U.S. Firms Finds One-Half Employ Foreign Scientists and Engineers," *Highlights*, NSF 85-336, February 28, 1986, and "Shortages Increase for Engineering Personnel in Industry," *Highlights*, NSF 85-309, March 29, 1985, are available from SRS/Office of the Division Director. Data for the 1986 survey are available from SAS/Industry Studies Group.

## PROJECT:
## Occupational Taxonomies for Computer Specialists

**Objective:**

To improve the detail and quality of information on computer specialists by developing a set of definitions or terms for occupations, job titles, and areas of specialization for the computer specialties field.

**Method:**

The project activities included researching existing occupational information and developing an initial taxonomy which was then refined on the basis of information collected through the use of a survey and through discussions with specialists in the field. The final taxonomy was reviewed by a panel of experts in occupational classification and data collection, representing industry, academia, and Government.

**Major Findings:**

The project resulted in the development of 11 new job categories that are intended to replace the single "computer specialist" classification used heretofore. The categories are as follows: Computer hardware specialist, computer operations specialist, computer scientist, computer software engineer, computer trainer, programmer, systems analyst, systems programmer, technical support specialist, telecommunications specialist, and other specialists in computer-related positions. The taxonomy will continue to undergo evaluation during the coming months.

**Responsible SRS Organization:**

Surveys and Analysis Section (SAS)/S/T Personnel Characteristics Studies Group

**Institution/Principal Investigator:**

American Federation of Information Processing Societies/Sylvia Charp

**Availability:**

*Development of Occupational Taxonomies for Computer Specialists*, Report, is available from SAS/S/T Personnel Characteristics Studies Group.

## PROJECT:
## Projected Response of the Science, Engineering, and Technical Labor Market to Defense and Nondefense Needs

**Objective:**

To project science, engineering, and technician (SET) personnel requirements of both defense and nondefense sectors through the year 2000; and to assess the adequacy of the project supply of such personnel available to meet those requirements. The supply projections are intended to identify potential problems within the SET labor market, as well as to assist in understanding the dynamics and flexibility of the SET labor supply.

**Method:**

Employment projections for the study will be generated through the use of the Defense Interindustry Forecasting System developed by Data Resources, Incorporated (DRI). These projections will use as a base the Bureau of Labor Statistics employment projections for the period 1984-95. The supply projections will be based on a model that incorporates all major sources of response to changes in demand.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section/Employment Studies Group

**Institution/Principal Investigator:**

Oklahoma State University/Robert DauffenBach

**Availability:**

A final report is expected in summer 1988 and will be available from the SRS/Office of the Division Director.

## PROJECT:
## The Qualities of Occupationally Mobile Scientists and Engineers

**Objective:**

Employers of scientists and engineers historically fill many vacancies with in-mobile workers rather than with new graduates whose degrees are in a field directly related to the occupation. This study seeks answers to questions about the qualitative functioning of the mobility process, including the extent of upgrading or transfer of workers from other occupations, the rate at which workers with previous experience in the occupation return, and the education and training necessary for each such group.

**Method:**

The study will present the results of tabulations, as well as correlation and regression analysis of the various measures by occupation and mobility status. Three data sources will be examined: The NSF Experienced Sample Surveys for 1972, 1974, 1976, and 1978; the 1982 Postcensal Survey; and data from the Current Population Surveys for 1973, 1978, 1981, and 1983.

**Major Findings:**

Preliminary analyses indicate that engineering occupations display the highest level of correlation with degree field, while the social sciences show the lowest.

**Responsible SRS Organization:**

Special Analytical Studies Section (SASS)/Employment Studies Group

**Institution/Principal Investigator:**

Oklahoma State University/Robert DauffenBach

**Availability:**

Results are expected in fall of 1987. To obtain a copy of the report, contact SASS/Employment Studies Group.

## PROJECT:
## Science and Technology Personnel Employed by the Federal Government

**Objective:**

To describe the patterns of employment of scientists, engineers, and technicians in the Federal Government and to provide information on trends in their utilization within Government in 1986. Characteristics of these Federal personnel include occupation, sex, race, age, educational attainment, agency of employment, salary, and work activity.

**Method:**

The Federal Office of Personnel Managment maintains a Central Personnel Data File that contains personnel records for individuals employed in all Federal agencies. NSF draws three sets of data from this file: One on professional scientists and engineers, another on technicians, and a final set on individuals who have science and engineering (S/E) degrees but are employed in non-S/E jobs.

**Major Findings:**

In 1986, the Federal Government employed nearly one-quarter of a million civilian scientists and engineers and over 100,000 technicians, making it the Nation's largest single employer of such personnel.

Federal employment is technologically more intensive than the total U.S. work force. About 1 in 6 Federal white-collar workers is a scientist or engineer, versus 1 in 16 nationally. One-quarter of the Federal scientists and engineers are engaged in research and development.

**Responsible SRS Organization:**

Surveys and Analysis Section/Government Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Federal Scientific and Technical Personnel: 1986*, Detailed Statistical Tables, sets of data diskettes will be obtainable gratis from NSF Diskette Service in early 1988 in accordance with procedures specified in Availability of Publications, p. xi; data also will be available on SRS Electronic Bulletin Board.

## PROJECT:
## Scientists, Engineers, and Technicians in Private Industry

**Objective:**

To provide data on employment of scientists, engineers, and technicians in the private sector by occupation and industry of employment.

**Method:**

Data are based on the Occupational Employment Statistics (OES) Survey of industrial establishments conducted by State Employment Security Agencies in cooperation with the Bureau of Labor Statistics. The State data are combined into national

employment estimates for Standard Industrial Classification (SIC) codes. This is an ongoing survey that began in 1977. Each year one of three subsectors covering manufacturing industries is surveyed. Survey data for 1977-85 have been integrated and extrapolated to provide national estimates of science, engineering, and technician (SET) employment through 1986 for all surveyed industries.

These estimates are benchmarked against total industrial employment derived from data provided on Form BLS 790, Report on Employment, Payroll, and Hours.

**Major Findings:**

The 1977-85 surveys show that the U.S. workplace is increasing in technological sophistication. Increases in the number of SET personnel have outpaced labor-force growth in manufacturing and nonmanufacturing industries. Even during the 1980-83 period of economic recession, the number of SET personnel grew 6% and total manufacturing employment dropped by 9%.

**Responsible SRS Organization:**

Surveys and Analysis Section (SAS)/Industry Studies Group

**Institution/Principal Investigator:**

Bureau of Labor Statistics/Brian MacDonald

**Availability:**

*Scientists, Engineers, and Technicians in Manufacturing Industries: 1983*, Detailed Statistical Tables, SRS 86-D5, set of two data diskettes in ASCII format is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Availability of Publications, p. xi. Data also are available on the SRS Electronic Bulletin Board. "Scientific and Technical Employment in Manufacturing Reaches 1.5 Million in 1985," *Highlights*, NSF 85-330, December 6, 1985. *Scientists, Engineers, and Technicians in Nonmanufacturing Industries: 1984*, Detailed Statistical Tables, SRS 86-D6, set of two diskettes in ASCII format is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Availability of Publications, p. xi. Data also are available on the SRS Electronic Bulletin Board. *Scientists, Engineers, and Technicians in Trade and Regulated Industries: 1985*, Detailed Statistical Tables, SRS 87-D8, set of two data diskettes in Lotus format is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Availability of Publications, p. xi. Data also are available on the SRS Electronic Bulletin Board.

## PROJECT:
## Workshop on Data Needs for Monitoring Labor-Market Conditions for Engineers

**Objective:**

To provide the National Science Foundation with information that will enable it to monitor more effectively the labor-market conditions encountered by the engineering work force.

**Method:**

The workshop participants will examine the similarities and differences among engineering-personnel data bases in terms of taxonomies, data elements, and data gaps.

**Major Findings:**

NA

**Responsible SRS Organization:**

Surveys and Analysis Section (SAS)/S/T Personnel Characteristics Studies Group

**Institution/Principal Investigator:**

National Research Council, Office of Scientific and Engineering Personnel/Linda S. Dix

**Availability:**

A report on the workshop proceedings will be available in the summer of 1988. For further information contact SAS/S/T Personnel Characteristics Studies Group.

## PROJECT:
## Workshop on the Underrepresentation and Career Differentials of Minorities in Science and Engineering

**Objective:**

To gain a better understanding of the origins of the underrepresentation of minorities in science and engineering.

**Method:**

A workshop was convened to review both the statistical trends of minority participation in science and engineering and the body of research that seeks to explain these differences. Four commissioned papers and formal critiques were presented.

**Major Findings:**

Many factors were cited as possible impediments to minority students' pursuit of coursework in mathematics, science, and engineering and to their success in science and engineering careers: Low socioeconomic status of the family; lower expectations held for minority students than for their white peers; insufficient counseling and remedial programs; inferior precollege educational opportunities; inadequate financial aid; lack of minority role models and mentors; and lack of well-organized recruitment and admissions programs.

**Responsible SRS Organization:**

Surveys and Analysis Section (SAS)/S/T Personnel Characteristics Studies Group

**Institution/Principal Investigator:**

National Research Council, Office of Scientific and Engineering Personnel/Linda S. Dix

**Availability:**

*Minorities: Their Underrepresentation and Career Differentials in Science and Engineering*, is available from the SAS/S/T Personnel Characteristics Studies Group. Paper copies @ $18.95 and microfiche @ $6.50 are available at the National Technical Information Service, Springfield, Virginia 22161, PB 87-189734.

## PROJECT:
## Workshop on the Underrepresentation and Career Differentials of Women in Science and Engineering

**Objective:**

To gain a better understanding of the reasons for underrepresentation of women in science and engineering.

**Method:**

A workshop was convened to review the causes of the observed underrepresentation and differential participation of women in science and engineering education and their differential career development relative to men. Four commissioned papers were presented.

**Major Findings:**

College-bound women lack adequate preparation in mathematics and physical science to pursue quantitatively-oriented science programs in college and, hence, quantitatively-oriented careers. Many colleges base admission on one's preparation in mathematics and physical science and on Scholastic Aptitude Test scores, reducing the pool of women eligible for admission to institutions and to programs that focus on engineering and science. Less financial aid is available for women students in science and engineering than for their male counterparts. Women enrolled in both undergraduate and graduate science courses show diminished self-confidence. Employers, whether in industry or academia, do not accommodate women scientists and engineers who choose to put their careers on hold briefly while giving birth and raising children.

**Responsible SRS Organization:**

Surveys and Analysis Section (SAS)/S/T Personnel Characteristics Studies Group

**Institution/Principal Investigator:**

National Research Council, Office of Scientific and Engineering Personnel/Linda S. Dix

**Availability:**

*Women: Their Underrepresentation and Career Differentials in Science and Engineering* is available from the SAS/S/T Personnel Characteristics Studies Group. Paper copies @ $18.95 and microfiche @ $6.50 are available at the National Technical Information Service, Springfield, Virginia 22161, PB 87-189726.

# section iii. financial resources

## a. government

## PROJECT:
## Federal R&D Funding

**Objective:**

To develop comprehensive data and analyses of research and development (R&D) funding levels and R&D plant programs of Federal agencies. To present data and analyses based on a survey of all agencies sponsoring R&D programs, covering such categories as basic research, applied research, development, performing sectors, fields of science and engineering, and geographic (State) distribution.

**Method:**

The survey is a recurring one, using a questionnaire that is sent annually to all Federal agencies that support R&D programs. Agency subdivisions that respond to the survey are, for the most part, budget offices where records are maintained of past and ongoing program levels and latest budget request levels. Responses to the 1986-88 (Volume XXXVI) survey were received and reviewed by NSF by mid-July 1987. They were processed by computer in the form of 163 detailed statistical tables.

**Major Findings:**

NA

**Responsible SRS Organization:**

Surveys and Analysis Section (SAS)/Government Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Federal Funds for Research and Development: Fiscal Years 1985, 1986, and 1987*, Volume XXXV, Detailed Statistical Tables, SRS 87-D1, set of 8 data diskettes in ASCII format, or 10 data diskettes in Lotus format, is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Availability of Publications, p. xi. Data also are available on the SRS Electronic Bulletin Board. *Federal Funds for Research and Development Historical Tables: Fiscal Years 1967-87* is unpublished and a limited number of copies are available from SAS/Government Studies Group.

## PROJECT:
## Federal R&D Programs by Budget Function

**Objective:**

This annual report provides a comprehensive overview of Federal research and development (R&D) programs and their funding levels as requested in the President's latest budget. It includes about 500 R&D programs categorized by the functions of the Federal budget, and analyses of the major R&D programs within each category.

**Method:**

Sources of funding data include reports provided by the agencies to the Office of Management and Budget for "Special Analysis J: Research and Development" in the 1988 budget presented in January 1987, agency budget-justification documents prepared for the Congress, and some information obtained informally. The data were compiled and arranged into the respective functional categories by NSF/SRS staff. Program descriptions were derived from budget documents.

**Major Findings:**

Total budget authority for all R&D programs, as proposed in the President's 1988 budget, is $67.6 billion, an increase of 16% over the 1987 request of $58.1 billion. In contrast, the total Federal 1988 budget authority increased 4% over the previous year. The scheduled growth in the 1988 budget continues to reflect the high priority placed on research and development considered essential for the foundation of the Nation's long-term objectives of a strong defense and economic security. Substantial increases in Federal R&D support were proposed for the Strategic Defense Initiative, space-station development, and Government-wide basic research. Reductions continue to be proposed for R&D programs of several agencies not regarded as an appropriate Federal responsibility, including shorter-term technology-development programs within the energy and the natural resources and environment functions. R&D priorities, measured in terms of shares of the total held by various functional areas, have continued to shift toward National Defense whose share is more than five times that of the next largest function, Health. In 1986 and 1987, National Defense accounted for 69% of total research and development, in 1988 its share increased to 70%.

**Responsible SRS Organization:**

Surveys and Analysis Section/Government Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Federal R&D Funding by Budget Function: Fiscal Years 1986-88*, Report, NSF 87-305, March 1987, available from SRS/Government Studies Group.

## PROJECT:
## Federal Support to the Academic and Nonprofit Sectors

**Objective:**

To develop annual data from the Federal agencies that fund the largest programs in support of academic and selected non-

profit institutional science and engineering (S/E) and non-S/E activities, particularly research and development.

**Method:**

Fifteen agencies received instruction booklets and institutional Code Books defining the obligations and disciplines concerned for FY 1985. Four major data elements were collected: Agency, name of institution, discipline, and activity (research and development, R&D plant, instructional facilities/equipment, fellowships/traineeships/training grants, general S/E support, and other S/E and non-S/E activities).

**Major Findings:**

Federal R&D support to individual universities and colleges totaled $6.4 billion in FY 1985, which is the most recent year for which detailed data are available. Federal academic support for all types of activities totaled $11.0 billion in FY 1985. Findings of the FY 1986 survey have not yet been fully tabulated.

**Responsible SRS Organization:**

Surveys and Analysis Section (SAS)/Government Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Federal Support to Universities, Colleges, and Selected Nonprofit Institutions: Fiscal Year 1985*, Detailed Statistical Tables, SRS 87-D2, set of 7 data diskettes in ASCII format, or set of 10 data diskettes in Lotus format, is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Availability of Publications, p. xi. Data also are available on the SRS Electronic Bulletin Board. Paper copies @ $18.95 and microfiche @ $6.50 are available from National Technical Information Service, Springfield, Virginia 22161, PB 87-202099/AS. Access to the public-use tapes and documentation for their use are described in the *Data User Guide*, January 1987, available from the SAS/Universities and Colleges Studies Group. A limited number of reports were published and are available from SAS/Government Studies Group.

# section iii. financial resources

## b. industry

## PROJECT:
## Biotechnology Research and Development in Industry

**Objective:**

To provide estimates of industry's financing of biotechnology research and development and employment of scientists and engineers working on biotechnology R&D projects during 1984 and 1985.

**Method:**

The report is based on information obtained from a survey of approximately 140 companies involved in biotechnology research and development.

**Major Findings:**

Performance of biotechnology research and development by industry amounted to an estimated $1.1 billion in 1985, a 20% increase over the previous year's level. The employment of scientists and engineers engaged in biotechnology R&D efforts increased by 12% between January 1985 and January 1986 to an estimated 8,000.

**Responsible SRS Organization:**

Special Analytical Studies Section/Economic Analysis Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

"Industrial Biotechnology R&D Performance Exceeded $1 Billion in 1985," *Highlights*, NSF 87-304, March 31, 1987, and *Biotechnology Research and Development Activities in Industry: 1984 and 1985*, Report, NSF 87-311, available from SRS/Office of the Division Director.

## PROJECT:
## Estimates of Company-Funded Industrial R&D Expenditures

**Objective:**

To provide estimates of companies' own financing of research and development in major industries for 1986-87 and to outline the factors that are or will be affecting the funding of these activities.

**Method:**

The report is based on information obtained from (1) mail responses to an inquiry sent to members of the NSF Industrial Panel on Science and Technology, and (2) interviews with research and development (R&D) officials representing firms in the major R&D-performing industries. Of the 92 company representatives contacted during April-June 1986, replies were received from 67. The respondents were asked to estimate the growth, if any, in company-funded R&D expenditures over the previous year for 1986 and 1987, and to provide the factors they believed to be responsible for any changes.

**Major Findings:**

Total company-funded expenditures for research and development in the United States are estimated to be $57 billion in 1986, an increase of about 7% over 1985. As of mid-1986, company R&D officials were anticipating about 5% growth in research and development for 1987. Three reasons were given for the lower, average-annual growth rate of 5.9% from 1985 to 1987 compared with 13.0% from 1975 to 1985: U.S. corporations' poor sales expectations in durable goods industries; concerns for short-time profitability, and the restructuring of R&D efforts after corporate mergers.

**Responsible SRS Organization:**

Surveys and Analysis Section/Industry Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

"Growth in Company-funded Research and Development Expected to Slow in 1987," *Highlights*, NSF 86-314, January 30, 1987, is available from SRS/Office of the Division Director. The *Highlights* based on mail responses to the 1987 survey will be available early in 1988.

## PROJECT:
## Industrial R&D Expenditures by State and Geographic Region

**Objective:**

To examine research and development (R&D) spending by industrial firms by State and region.

**Method:**

Data from the annual survey of industrial research and development will be analyzed to determine the magnitude of R&D spending by the major R&D-performing industries by State between 1981 and 1985.

**Major Findings:**

NA

**Responsible SRS Organization:**

Surveys and Analysis Section/Industry Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

It is expected that this report will become available in 1988 from SRS/Office of the Division Director.

## PROJECT:
## Impact of Foreign R&D Funding on U.S. Private R&D Spending

**Objective:**

To examine the impact of foreign expenditures on industrial research and development. It is hypothesized that industrial research and development in Japan and in Europe will elicit a competitive response in the United States.

**Method:**

Expenditures on industrial research and development in Japan and in Europe are included in regression equations in which private research and development (R&D) expenditures in the United States constitute the dependent variable. Data on scientists and engineers engaged in research and development in industry are used to confirm the results of the first phase.

**Major Findings:**

The ability of regression models to predict private industrial R&D expenditures tends to improve when foreign R&D expenditures are included: Japanese industrial research and development appears to elicit a stronger reaction from U.S. firms than does European R&D expenditures. There is evidence that industrial R&D expenditures by different countries are interdependent.

**Responsible SRS Organization:**

Special Analytical Studies Section/Science Indicators Studies Group

**Institution/Principal Investigator:**

National Planning Association/Nestor Terleckyj

**Availability:**

Results are available from the National Planning Association, 1616 P Street, N.W., Suite 400, Washington, D.C. 20036.

## PROJECT:
## Research and Development in Industry

**Objective:**

To provide data on the resources allocated to research and development by domestic firms. These statistics are collected annually and provide historical trend information in addition to current survey-year data.

**Method:**

The annual Survey of Industrial Research and Development is conducted by the Bureau of the Census for NSF. Companies surveyed are selected quinquennially from a sample of firms in all manufacturing and selected nonmanufacturing industries. Companies spending at least $1 million annually on research and development are surveyed each year. Firms spending less are not surveyed annually, but data for them are estimated by the Census Bureau.

**Major Findings:**

Preliminary data from the 1985 Survey of Industrial Research and Development indicate that R&D expenditures totaled $78.2 billion in 1985, a constant-dollar increase of 6.5% over the previous year's level. Industry's R&D performance has grown steadily since 1975: combined company and Federal funding, in real terms, increased at an average annual rate of about 6% between 1975 and 1985. The Federal portion of industrial R&D expenditures ($26.4 billion) increased about 10% in constant dollars whereas industry's own R&D spending ($51.8 billion) increased 5% during 1985. Preliminary data indicate that the number of full-time-equivalent scientists and engineers in industry rose 5% during 1985 to a total of approximately 600,000.

**Responsible SRS Organization:**

Surveys and Analysis Section (SAS)/Industry Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Research and Development in Industry: 1985*, Detailed Statistical Tables, SRS 87-D7, one data diskette in ASCII format, or two data diskettes in Lotus format, are obtainable gratis from NSF Diskette Service in accordance with procedures specified in Availability of Publications, p. xi. Data also are available on the SRS Electronic Bulletin Board.

# section iii. financial resources

## c. universities and colleges

## PROJECT:
## Academic Employment of Scientists and Engineers

**Objective:**

To provide annual quantitative information on professional science and engineering (S/E) personnel employed in universities and colleges.

**Method:**

All 333 doctorate-granting institutions with S/E programs received the questionnaire for the January 1987 survey. Data elements were discipline of employment, employment status (full- or part-time) by sex, and total and R&D full-time equivalents.

**Major Findings:**

NA

**Responsible SRS Organization:**

Surveys and Analysis Section (SAS)/Universities and Colleges Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Academic Science/Engineering: Scientists and Engineers, January 1985*, Detailed Statistical Tables, SRS 86-D4, set of four data diskettes in ASCII format, or five diskettes in Lotus format, is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Availability of Publications, p. xi. Data also are available on the SRS Electronic Bulletin Board. Paper copies @ $16.95 and microfiche @ $5.95 are available from National Technical Information Service, Springfield, Virginia 22161, PB 86-215266/AS. Access to the public-use tapes and documentation for their use are described in the February 1986 *Data User Guide* which is available from the SAS/Universities and Colleges Studies Group.

## PROJECT:
## Academic-Research Instruments in Academic Settings

**Objective:**

To analyze the status of, and need for, scientific-research equipment in U.S. universities and colleges in 1985-86 through a nationally representative survey of higher-education institutions. This study builds on and continues the first "baseline" study of academic instrumentation which was conducted in 1982-83.

**Method:**

The contractor conducted a stratified probability sample survey of 55 universities from a universe of the approximately 174 largest academic research and development (R&D) performers. During Phase I of the survey, departments within universities were subsampled in the physical and computer sciences and engineering to collect information on equipment costing between $10,000 and $1,000,000. During Phase II of the study, departments will be subsampled in the biological, agricultural, environmental, and medical sciences.

**Major Findings:**

In FY 1985, estimated total expenditures for purchase of non-expendable, university-research equipment were $157 million in engineering; $166 million in the physical sciences, and $47 million in computer science. Federal agencies were the source of funds for 51% of all FY 1985 expenditures for purchases of research equipment in Phase I fields. The Federal contribution to FY 1985 equipment funding was 63% in the physical sciences, 40% in computer science, and 40% in engineering. The median age of equipment systems in Phase I fields in 1985 was 3 years. In 1985, the median age of all computer-science instrument systems was 2 years, as compared to 4 years per system in both engineering and the physical sciences. Most department heads identified equipment in the $10,000-$1,000,000 range as being the top priority for increased Federal assistance for research instrumentation.

**Responsible SRS Organization:**

Surveys and Analysis Section/Universities and Colleges Studies Group

**Institution/Principal Investigator:**

Westat, Inc./Lance Hodes

**Availability:**

A *Highlights* is being prepared for early fall 1987 publication, and will be available from the SRS/Office of the Division Director. A final report on Phase I, *Academic Research Equipment in the Physical and Computer Sciences and Engineering: 1982 and 1985*, has been issued by Westat, Inc.; a combined report on Phases I and II will be issued in fall 1988. *Academic Research Equipment in the Physical and Computer Sciences: 1982 and 1985*, Detailed Statistical Tables, SRS 87-D6, set of six data diskettes in ASCII format is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Availability of Publications, p. xi. Data also are available on the SRS Electronic Bulletin Board.

## PROJECT:
## Academic Science and Engineering Research Facilities

**Objective:**

To develop quantitative indicators of the status and condition of research facilities in U.S. universities and colleges through

a nationally representative biennial survey of higher education institutions, in response to a Congressional mandate.

**Method:**

During the 1987/88 academic year, a contractor will conduct a stratified probability sample of approximately 250 universities and colleges covering the major science and engineering disciplines.

**Major Findings:**

NA

**Responsible SRS Organization:**

Surveys and Analysis Section/Universities and Colleges Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

A comprehensive report will be issued by a contractor in September 1988; a separate report covering the medical sciences will also be issued by the National Institutes of Health at that time.

## PROJECT:
## R&D Funds in Academic Science and Engineering

**Objective:**

To collect annual data from academic institutions spending over $50,000 for separately budgeted research and development.

**Method:**

Beginning in 1984 this survey was converted to a sample of about 400 institutions that include all scientific and engineering (S/E) doctorate-granting institutions with certainty, all historically black universities and colleges, 17 affiliated federally funded research and development (R&D) centers, and a probability sample of the remaining institutions. There were several data elements: Source of support, amount allocated to basic research, total and federally financed R&D expenditures by S/E discipline, research equipment expenditures from separately budgeted R&D funds by discipline, and capital expenditures for S/E activities.

**Major Findings:**

Academic separately budgeted R&D programs in S/E activities totaled $9.5 billion in 1985, up nearly 12% (8% in constant dollars) over 1984 levels, and it is estimated that they will reach $10.5 billion in 1986, up an average of 8% per year in real terms during the 1984-86 period. Federally financed R&D spending rose 11% in 1985 to more than $6 billion and is expected to reach about $6.8 billion in 1986, continuing the significant growth seen in 1984 after two years of barely keeping pace with inflation. Academic basic research rose 9% in real dollars in 1985, while growth in Federal funds devoted to fundamental research outpaced inflation for the first time since 1981, up 9% over 1984 levels. Expenditures for S/E equipment accounted for about 7% of total academic R&D spending. Findings of the 1986 survey have not yet been completely analyzed.

**Responsible SRS Organization:**

Surveys and Analysis Section (SAS)/Universities and Colleges Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

"Academic R&D Expenditures Expected to Continue Substantial Growth Through FY 1986," *Highlights*, NSF 87-302, April 17, 1987, is available from SAS/Universities and Colleges Studies Group. Access to the public-use tapes and documentation for their use are described in the January 1987 *Data User Guide*, available from SAS/Universities and Colleges Studies Group. *Academic Science/Engineering: R&D Funds, Fiscal Year 1985*, Detailed Statistical Tables, SRS 87-D3, set of five data diskettes in ASCII format, or six diskettes in Lotus format, is obtainable gratis from NSF Diskette Service in accordance with procedures specified in Availability of Publications, p. xi. Data also are available on the SRS Electronic Bulletin Board. Paper copies @ $18.95 and microfiche @ $6.50 are available from National Technical Information Service, Springfield, Virginia 22161, PB 87-199600/AS.

## PROJECT:
## Science and Engineering Research Facilities at Doctorate-Granting Institutions

**Objective:**

To collect and analyze data "identifying and assessing the research-facilities needs of universities" and to report findings to Congress as required in the 1986 NSF authorization bill (H.R. 1210). A biennial survey series is being developed to meet continuing Congressional reporting requirements.

**Method:**

Two surveys were conducted in spring 1986. One collected baseline quantitative data from 165 doctorate-granting institutions on the amount of space devoted to research and development; the costs associated with major repairs, upgrading, and new construction; and the age of facilities. The second survey solicited the opinions of 80 research administrators and

175 deans on the condition of research facilities, the adequacy of space, the priority given to facilities-related concerns, the effects of facilities constraints on research, and the problems encountered addressing the needs.

**Major Findings:**

Facilities-related activities (major repairs, renovations, or new construction) are in progress or planned at almost all doctorate-granting institutions. Schools ranked in the top 50 in terms of research and development (R&D) expenditures, however, accounted for more than half of the facilities-related expenditures and more than half of the facilities-related space, planned as well as current.

When completed, new construction currently in progress will increase research space at doctorate-granting institutions by as much as 7%. New construction planned between 1986 and 1991 will increase existing space by as much as 19%.

In academic year 1985/86, the estimated cost of completing all facilities-related work in progress was $1.7 billion. The cost to complete work planned between 1986 and 1991 was estimated to be $5.8 billion. The top 50 schools accounted for over 50% of the costs of work in progress and over 60% of the estimated costs for planned work.

**Responsible SRS Organization:**

Surveys and Analysis Section/S/E Education Sector Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*Science and Engineering Research Facilities at Doctorate-Granting Institutions*, Report, unnumbered, is available from SRS/Office of the Division Director.

# section iv. outputs and impacts

## a. innovations and inventions

## PROJECT:
## Aggregate Indicators of Technology and Technology Innovation

**Objective:**

To extend the investigator's previous study on computers to provide a general method for measuring the advance of an industry's technological performance through time.

**Method:**

Three industries will be selected from such possibilities as general-purpose assembly robots, logic analyzers, and solar energy. Data on firms will be collected and used in further studies of technology transfer, the effect of firm size on innovativeness, and the relation between research and development (R&D) expenditure and innovation output.

Cost is regressed against performance and date of introduction for all models of the technology. Performance will be measured in terms of the value of the product to users.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section (SASS)/Science Indicators Studies Group

**Institution/Principal Investigator:**

University of Texas/Kenneth E. Knight

**Availability:**

A final report is expected to become available in late 1987 from SASS/Science Indicators Studies Group.

## PROJECT:
## Developing New Indicators of Input into Science and Technology

**Objective:**

To test the utility of state-of-the-art survey research methods to generate indicators of the participation of university and college science and engineering (S/E) faculty in paid, private, off-campus consulting and research and development (R&D) work. Another issue to be explored is the hypothesis that college and university S/E faculty who engaged in off-campus consulting and research and development play a particularly strong role in small, innovative industrial firms.

**Method.**

The study was limited to full-time S/E faculty at doctoral/research institutions and universities and comprehensive colleges (as classified by the Carnegie Council in 1976 and as updated by the National Center for Education Statistics in 1980). A total of 1,200 scientists and engineers was interviewed by telephone regarding the nature and extent of paid, private, and off-campus consulting and R&D work during 1984. A subsample of these scientists and engineers were interviewed in person to validate the findings from the telephone interviews. In addition, a limited number of off-campus employers of faculty consultants were interviewed to generate additional information regarding the validity of faculty respondents' statements about the nature of their contributions.

**Major Findings:**

Findings on the recent consulting activity of respondents show the development of a measurable indicator. Data from the 1984 telephone survey reveal the distribution of S/E faculty consulting by region, teaching field, type of institution, and combinations of these three variables. Overall, 64% of faculty in 1984 and again in 1986 report having had recent consulting experience. This finding suggests strong reliability of both the indicator and the interview method.

An additional indicator of faculty consulting is reported: "career" consulting; a measure of whether faculty have done consulting at any time during their careers. A descriptive account of S/E faculty consulting is given showing the distribution of those who consult by teaching field, type of institution, sex and age of respondent, consulting for small business, technology level of firm, sources of consulting, and types of clients.

Additional funding of the project in 1985 provided resources for conducting a followup panel in the fall of 1986 and an exploratory client study. The panel shows the feasibility of monitoring faculty-consulting activity over time. The client study describes industry-university relations. Several indicators including hiring, availability, services, contribution, and future use of faculty by industry are presented.

A description of faculty academic research, a discussion of the National Center for Educational Statistics and 1976 Carnegie Classification schemes, the 1984 letter to participants, a complete frequency listing of the 1984 survey questions, and the four research instruments are found in the appendices.

**Responsible SRS Organization:**

Special Analytical Studies Section/Science Indicators Studies Group

**Institution/Principal Investigators:**

Foundation of California State University, Sacramento/Frank Darknell and David Nasatir

**Availability:**

Final report is available from the Principal Investigators.

## PROJECT:
## An Exploration into the Quality Dimension of Patents

**Objective:**

To investigate the economic value of granted patents to the patent holder. To develop an approach to correcting counts of patents so as to allow for variations in patent values. In these terms, to estimate in selected cases whether trends in patenting are good representations of trends in valuable patents, and thereby to improve the understanding of patent counts as indicators of technical invention.

**Method:**

Data will be obtained from the French patent office on patents classified by technology and country of origin, and on the payment of periodic renewal fees for those patents. An econometric model will be developed to represent the declining returns to the owner at different patent ages as revealed by the payment of the renewal fees.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section/Science Indicators Studies Group

**Institution/Principal Investigator:**

National Bureau of Economic Research/Mark Schankerman

**Availability:**

Project report expected to be available from the Principal Investigator in late 1988.

## PROJECT:
## A Sample Survey of Industrial Innovation in the United States

**Objective:**

To collect data on indicators of technological innovation from a sample of at least 2,000 manufacturing firms in the United States.

**Method:**

The principal investigator collected, via a mail survey, data on new indicators of industrial innovation from a sample of manufacturing firms in the United States. The survey instrument used was originally developed by the Center for Policy Alternatives at the Massachusetts Institute of Technology under an NSF-funded grant. The feasibility of collecting these data via a mail survey was demonstrated through an NSF-funded pilot study conducted by Boston University. The current project developed a methodology for selecting a statistically valid sample of at least 2,000 firms, conducting the survey, tabulating the results, and analyzing the findings.

**Major Findings:**

The study indicated that, on the average, about 40% of the cost of introducing a new product can be attributed to research and development. Smaller companies (under $350 million in sales) attributed a larger proportion to research and development than did larger firms (42% versus 33%). The proportion attributable to research and development ranged from 26% in the food industry to 50% in the electrical-equipment industry.

**Responsible SRS Organization:**

Special Analytical Studies Section (SASS)/Economic Analysis Studies Group

**Institution/Principal Investigator:**

Audits & Surveys/Stanley M. Zdep

**Availability:**

A summary of the findings is available from the SASS/Economic Analysis Studies Group.

# section iv. outputs and impacts

## b. bibliometrics

## PROJECT:
## Measures of Innovation and Productivity in Industry

**Objective:**

To develop counts of technological innovations produced in three U.S. industries: Chemicals, textiles, and machine tools, from 1967 to 1984. To develop a method of rating these innovations by quality. To study innovation trends and relate them to trends in industrial productivity.

**Method:**

Innovations are identified from trade literature. They are then graded by consulting experts in the specific technologies. Productivity trends are interpreted in terms of trends in different types of innovation through interviews with company representatives.

**Major Findings:**

The chemical and textile industries had greatly different productivity trends in the period studied. In both cases, the study of innovation trends assisted materially in interpreting the productivity data.

**Responsible SRS Organization:**

Special Analytical Studies Section/Science Indicators Studies Group

**Institution/Principal Investigator:**

Drexel University/Alok K. Chakrabarti

**Availability:**

Final report is expected to be available from the Principal Investigator in late 1987. Published papers can also be requested from the Investigator.

## PROJECT:
## Measuring the Growth of Knowledge in the Biomedical Sciences

**Objective:**

To develop and test bibliometric techniques for measuring the growth and decline of scientific specialties in the biomedical field.

**Method:**

Research grants made by the National Institutes of Health (NIH) were divided into subject area specialties within biomedicine. This was done by cluster analysis of key words appearing in the grant titles and teams assigned by professional indexers. Changes in cluster size represented changes in the amount of work being done in the corresponding specialty. Interviews with senior scientists were used to check the results of the cluster analysis.

**Major Findings:**

Clusters obtained from the NIH data base are intellectually coherent and represent well-defined areas of scientific knowledge. Scientists whose NIH grants belong to the same specialty cluster also exhibit a certain degree of professional affiliation and interaction as co-workers. Their shared interests are evidenced by their patterns of frequent communication.

**Responsible SRS Organization:**

Special Analytical Studies Section/Science Indicators Studies Group

**Institution/Principal Investigator:**

Stanford University/Everett M. Rogers

**Availability:**

The final report can be obtained from the Principal Investigator.

## PROJECT:
## Testing a Typology of R&D Laboratories Operating in the United States

**Objective:**

To refine and test a typology of research and development organizations, and to develop measures of the organizational features common to laboratories that operate under different forms of ownership: Private industry, Government, quasi-Government, and nonprofit.

**Method:**

From a universe of about 16,000 laboratories derived from a variety of sources, a sample of 1,300 will be surveyed by mail to determine organizational characteristics including history, organizational structure, types of research activity, sources of funds, numbers and characteristics of personnel, and the like.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section/Science Indicators Studies Group

**Institution/Principal Investigators:**

Syracuse University/Barry Bozeman, and Iowa University/Michael M. Crow

**Availability:**

A report is expected by summer of 1988.

# section iv. outputs and impacts

## c. economic and social implications

## PROJECT:
## The Impacts of Science on Society in the United States

**Objective:**

To investigate the means by which impacts of science on U.S. society might be observed and measured, thus laying the conceptual and methodological groundwork for a possible expansion of the indicators gathered by NSF.

**Method:**

This exploratory project consisted of two steps: The commissioning of a set of papers on the project theme, and the holding of a workshop to compare the papers and synthesize their findings. The papers took as their starting point the "knowledge system in society" which consists of the institutions, organizations, groups, and roles that conduct knowledge-related activities. Papers were prepared by experts in the domains of education, information science, public policy, economics, etc. The workshop was held in early May 1987.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section/Science Indicators Studies Group

**Institution/Principal Investigators:**

University of Pittsburgh/Burkart Holzner, William Dunn

**Availability:**

Condensed versions of the papers will be published in fall 1987 as a special volume of the journal titled, *Knowledge: Creation, Diffusion, Utilization* (Sage Publications). Full versions of the papers and the Principal Investigators' conceptual framework will be edited and published as a book in 1988.

## PROJECT:
## Organizational and Strategic Factors Affecting the Distribution of Returns from Innovation and International Technology Transfer

**Objective:**

To identify, measure, and analyze the factors that affect the ability of firms to profitably exploit innovations abroad.

**Method:**

The project has proceeded in three phases. First, a conceptual framework was developed linking the private returns to innovation to the innovator's organizational structure. Second, data were collected and analyzed following three lines of analysis: Joint ventures and collaborative arrangements in biotechnology; a cross-industry analysis of joint ventures and collaborative arrangements; and an analysis of innovator's performance as a function of strategy and structure within the computer industry. The data collected so far in these three studies will be used to investigate the hypothesis that the profitability of an innovation to an innovator depends largely on the position of the innovating firm within its industrial structure.

**Major Findings:**

Interim results are provided in David J. Teece, "Transactions Cost Economics and the Multinational Enterprise: An Assessment," *Journal of Economic Behavior and Organization*, vol. 7 (1986), pp. 21-45, and in David J. Teece, "Profiting from Technological Innovation: Implications for Integration, Collaborations, Licensing and Public Policy," *Research Policy*, vol. 15, no. 6 (December 1986), pp. 285-305.

**Responsible SRS Organization:**

Special Analytical Studies Section/Science Indicators Studies Group

**Institution/Principal Investigator:**

University of California, Berkeley/David J. Teece

**Availability:**

A final report is expected late in 1987.

# section iv. outputs and impacts

## d. other

## PROJECT:
## Impact of Technological Accidents on Public Attitudes Toward Science and Technology

**Objective:**

To assess the impact of the widely publicized technological accidents involving the Shuttle Challenger and the Chernobyl nuclear reactor on public attitudes in the United States toward science and technology.

**Method:**

Telephone interviewing was done with a sample whose attitudes toward science and technology had previously been studied in November 1985. This group was reinterviewed in February 1986 after the Shuttle accident, and again in June 1986 after the Chernobyl accident and the publication of the Rogers Commission Report of the Shuttle accident.

**Major Findings:**

Support for the Shuttle program continued to be high, in spite of increased perception of design and management errors and some erosion of support after the Rogers Commission Report. No general rejection of nuclear power was expressed, though responses did not always seem consistent. Expressions of support for science and technology in general actually increased after the Shuttle accident.

**Responsible SRS Organization:**

Special Analytical Studies Section/Science Indicators Studies Group

**Institution/Principal Investigator:**

Northern Illinois University/Jon D. Miller

**Availability:**

Final project report available from the Principal Investigator.

## PROJECT:
## State Science Indicators

**Objective:**

To investigate the feasibility of developing State-level indicators of science and technology.

**Method:**

The project will describe the science and technology (S/T) activities of 12 States, and will attempt to identify indicators of these activities that can be used for ongoing collection of State-level S/T data.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section (SASS)/Science Indicators Studies Group

**Institution/Principal Investigator:**

Syracuse Research Corporation/W. Henry Lambright

**Availability:**

A report is expected by summer 1988.

## PROJECT:
## A Workshop on New Indicators of University/ Industry R&D Interactions

**Objective:**

To improve understanding, and to track the characteristics, of industrial support for academic research and development.

**Method:**

Alternative means of capturing data on industrial support of academic research and development will be discussed at a workshop composed of a subset of research administrators at major research universities. These officials will return to their institutions and explore the feasibility of implementing suggested changes in data handling. A followup meeting will be held to discuss the results and to formulate a final report.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section/Science Indicators Studies Group

**Institution/Principal Investigator:**

University of Florida at Gainesville/Thomas Walsh

**Availability:**

A report is expected by fall 1988.

# section v. international science and technology

## PROJECT:
## Areas of Leading-Edge Japanese Science and Technology

**Objective:**

To identify specific areas of leading-edge Japanese science and technology and to identify major areas of difference between U.S. and Japanese scientific and technological (S/T) emphases.

**Method:**

Scientific literature data (based on the Science Citation Index) and U.S. patent data will be refined, compiled, and analyzed. The findings will be presented in a format which will allow immediate comprehension of the S/T emphases.

**Major Findings:**

In both science and technology similar patterns emerge. The Japanese share is growing steadily while the U.S. share is shrinking or, at best, holding relatively constant. In science the Japanese show a particular emphasis in chemistry and physics with an average emphasis in bioscience. In contrast, the United States shows a special emphasis in earth and space science and notable emphasis in clinical medicine and biomedicine. Over the period 1975-84, the share of U.S. patents with Japanese inventors increased from 9% to 17%. The Japanese patents are concentrated in relatively high-technology classes related especially to those areas of consumer products where there is a major Japanese presence, including electronics, photography, and automotive technology. The Japanese are patenting in the most frequently cited and rapidly-developing areas of science. Among the most highly-cited patents, which can be considered to have particular technical impact and quality, the Japanese have 30% to 50% more patents than expected. The areas in which the Japanese have substantial numbers of very highly-cited patents are automotive technology, semi-conductor electronics, photocopying and photography, and pharmaceuticals and pharmaceutical chemistry. The implication for all is that the Japanese position is patented technology is strong, growing, and based on high-quality, high-impact technology.

**Responsible SRS Organization:**

Special Analytical Studies Section (SASS)/International Studies Group

**Institution/Principal Investigator:**

Computer Horizons, Inc./Francis Narin

**Availability:**

*Identifying Areas of Leading-Edge Japanese Science and Technology: First Interim Report "Activity Analysis Using SIC Categories and Scientific Subfields"* and *Identifying Areas of Leading-Edge Japanese Science and Technology: Second Interim Report "Patent Activity and Citation Analysis Using U.S. POC Classification."* Available from Computer Horizons, Inc., 1050 Kings Highway North, Cherry Hill, New Jersey 08034. Paper copies @ $13.95 and microfiche @ $6.50 are also available for the First Interim Report (PB 87-204087/AS) as well as for the Second (PB 87-204095/AS) at the National Technical Information Service, Springfield, Virginia 22161.

## PROJECT:
## The Development of Science and Technology Capacity in Newly Industrializing Nations

**Objective:**

To examine the evolution of institutions for training scientific and technological (S/T) personnel in the newly industrializing nations of South Korea, Taiwan, Malaysia, and Singapore as well as the research that is carried out within them in key scientific fields; to examine the contribution of university-based scientists to industrial and technological development through an analysis of their publications, consulting activities, and related professional work; and to investigate the roles played by graduates of academic institutions in industry, research, and education. In brief, the project aims to portray the scientific capacity of academic institutions, their importance in training S/T manpower for national needs, and the ways in which research produced in these institutions are used locally.

**Method:**

The project director and senior consultant will coordinate four country studies executed by indigenous researchers. A variety of research strategies will be used to obtain data: Field research in selected institutions; interviews with Government scientific and educational authorities; and use of the *Science Citation Index*, *Who's Publishing in Science*, the *Directory of Scholars in Southeast Asia*, and other sources. Care will be exercised to ensure that a common conceptual framework is used and that comparable data are collected in each country.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section (SASS)/International Studies Group

**Institution/Principal Investigator:**

State University of New York-Buffalo/Philip Altbach

**Availability:**

The final report is expected to become available from SASS/International Studies Group in fall 1988.

## PROJECT:
## Government Funding of Academic Research in Selected Countries

**Objective:**

To compile and assess statistics showing how much the United States, United Kingdom, Japanese, French, West German, and Dutch Governments spent in 1984, 1986, and to the extent possible, 1987, on academic and related research.

**Method:**

The project will build on a previous study which produced similar data for 1975, 1980, and 1982. The cooperation of government officials has been secured to assist in providing the data at the level of detail necessary. The data will be collected on site and in consultation with the cognizant officials and policymakers. Data will be provided not only for total expenditures but also will be disaggregated into 9 fields and 40 subfields.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section (SASS)/International Studies Group

**Institution/Principal Investigators:**

University of Sussex/John Irvine and Ben Martin

**Availability:**

Final report is expected in late 1988.

## PROJECT:
## International Comparisons of Innovation Indicators

**Objective:**

To collect available empirical studies of industrial innovation conducted in the United States and in a number of foreign countries. To summarize and compare the methodologies and definitions employed in these studies and compare their outputs and results.

**Method:**

Recorded information concerning recent and ongoing innovation indicator projects were identified, collected, compared, and analyzed. Onsite interviews were conducted with researchers of a significant number of these projects in order to obtain additional information concerning the definitions used, response rates, followup techniques, and other characteristics and procedures used that led to successful survey results. Information concerning recent results that may not have been reported in written form were also sought.

**Major Findings:**

The project studied two surveys in West Germany and one in each of the countries of the United Kingdom, Canada, France, Italy, the Netherlands, and the United States. The surveys could be grouped into those that involved direct surveys of industrial firms, and those that collected data focused more on the innovative output of the first than on the innovation inputs. Although the surveys were quite different, both were found to be useful. The innovation-based surveys provide information that can be used as measures of innovative output, and data from such surveys are amenable to the development of longitudinal studies and analyses of the inter-industry technology flows. The firm-based data provide information concerning intermediate stages in the innovation process. The following frequently-asked questions and topics are addressed by the surveys: Sources of innovation; innovation counts; percentage of sales from previous years attributable to new products; expenditures on innovation activities downstream from research; the objectives of innovation; obstacles to innovation; the organization of research; the users of new technology; the significance of innovation; and the length of time required to develop innovations.

**Responsible SRS Organization:**

Special Analytical Studies Section (SASS)/International Studies Group

**Institution/Principal Investigator:**

State University of New York, College at Fredonia/John A. Hansen

**Availability:**

The final report, *International Comparisons of Innovation Indicator Development*, is available from SASS/International Studies Group.

## PROJECT:
## International Flow of Scientists and Engineers into the U.S. Science and Technology System

**Objective:**

To improve understanding of the international flow of scientists and engineers.

**Method:**

Data from a resurvey of major U.S. scientific laboratories and existing data from NSF-sponsored surveys of scientists and engineers in the United States will be used. The information to be developed from these sources will include disaggregation

of immigrant data by country/continent of birth, new estimates of emigration (from the United States) of foreign scientists and engineers working in the United States, estimates of changes in the level of foreign participation at major U.S. laboratories, 1981-85, and estimates of temporary visits to foreign countries by U.S. personnel from major U.S. laboratories.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section/International Studies Group

**Institution/Principal Investigators:**

Oak Ridge Associated Universities/Larry Blair and Michael G. Finn

**Availability:**

Final report is expected in early 1988.

## PROJECT:
## International Training of Foreign Scientists and Engineers

**Objective:**

To examine the international flow of foreign graduate students and postdoctoral scientists and engineers to universities in the leading industrial nations of the West and Japan and to explore the ways in which their training is used.

**Method:**

This study will include four major efforts: (1) Preparing an overview of the international movement of foreign science and engineering students in the United States, France, the Federal Republic of Germany, Japan, and the United Kingdom; (2) surveying five U.S. universities that have large percentages of foreign students, the majority of whom are enrolled in science or enginering; (3) preparing cross-national study of three university departments (electrical engineering, molecular biology, and solid-state physics) in each of the aforementioned five countries; and, (4) interviewing policymakers in the respective countries and analyzing the stated policies of these countries to learn the basis for interpreting the empirical patterns.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section/International Studies Group

**Institution/Principal Investigator:**

Harvard University/Dorothy S. Zinberg

**Availability:**

The final report is expected in fall 1988.

## PROJECT:
## Japanese Science and Technology Resources

**Objective:**

To examine quantitative information on the financial and human resources being invested in Japanese scientific and technological (S/T) activities, and to provide S/T data on Japan that are more detailed and more comparable with U.S. definitions than have been available previously.

**Method:**

Heretofore underutilized data on Japanese S/T resources will be compiled, evaluated, and analyzed. Various Japanese survey instruments used to collect the data will be examined and compared. New Japanese time series that will be constructed and compared with U.S. data include those on the total number of scientists and engineers cross-classified by subfield and industry group; total Japanese scientists and engineers by occupation, and sector; Japanese expenditures on basic research, and Japanese academic institutions' research and development expenditures. Research will be conducted in both the United States and Japan.

**Major Findings:**

Preliminary findings indicate that there was (1) less basic research conducted in Japan between the early 1950's and mid-1970's than previously believed; (2) a smaller role for the Government in promoting and conducting research and development during this period, and (3) a less important role for university-based research. These new time series also indicate that since the mid-1970's (1) the growth rate of basic research has been faster than previously believed; (2) the Japanese Government's role in promoting basic research has grown rapidly, and (3) the role of universities in performing basic and applied research has also grown much more rapidly than previously believed.

Japanese scientific and engineering (S/E) personnel receive far less postgraduate academic education than their U.S. counterparts. At the same time, Japanese scientists and engineers benefit from relatively greater within-firm training opportunities.

The differing locus and emphasis of postgraduate training in Japan has led to much lower mobility of S/E personnel between firms than in the United States or even in Western Europe. New estimates indicate that the mobility of scientists and engineers in Japan is lower than the mobility of the labor force in general and in particular is lower than that of all other classes of professional and administrative personnel, excepting only Government employees. This is different from the pattern found in the United States.

The lower, inter-firm mobility exhibited by Japanese scientists and engineers and the different patterns of training readily suggest that there is less informal communication between scientists and engineers at unrelated firms in Japan than in the United States. Japanese company scientists and engineers are less likely to attend professional association meetings than their U.S. counterparts and when attending such meetings they are also less likely to present a paper detailing research findings.

**Responsible SRS Organization:**

Special Analytical Studies Section/International Studies Group

**Institution/Principal Investigator:**

University of Michigan/Gary Saxonhouse

**Availability:**

The final report is expected to become available from the Principal Investigator in fall 1987.

## PROJECT: Patent-Based Technology Indicators by Industry

**Objective:**

To develop a new international set of technology indicators for a number of countries from 1968 to the present. Patents granted by industry-of-origin and industry-of-use will form the basis for these indicators.

**Method:**

A concordance between the International Patent Classes (IPC) and the International Standard Industrial Code Classification will be developed on both an industry-of-use and industry-of-origin basis. The Canadian Patent Office has produced a data set for its country's patents which will be used as a model. Foreign patent data will then be classified and analyzed according to these categories. The investigator will also provide a qualitative report on the patent protocols of leading advanced societies that should be helpful in interpreting patent indicators.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section/International Studies Group

**Institution/Principal Investigator:**

Yale University/Robert E. Evenson

**Availability:**

The final report will be available in spring 1989.

## PROJECT: R&D Expenditures in Selected Industrialized Countries

**Objective:**

To expand the research- and development (R&D)-expenditure data base for selected industrialized countries, namely Japan, West Germany, France, and the United Kingdom.

**Method:**

Onsite data teams will identify foreign data sources. Data will be collected through direct contacts with officials from various sectors including government, industry, higher education, and nonprofit institutions. Reports, surveys, and other literature published in the national language will be examined. An examination of the comparability of the foreign data will be done in terms of U.S. definitions and concepts. Analytical analyses will be conducted on the foreign R&D data and comparisons will be made with U.S. R&D data trends.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section (SASS)/International Studies Group

**Institution/Principal Investigator:**

SRI International/Catherine P. Ailes

**Availability:**

A final report and data diskettes of tables for each individual country are expected to become available from SASS/International Studies Group in fall 1987. Also see *Performer Organizations and Support Strategies for Fundamental Research: United States, France, West Germany, United Kingdom, Japan, Soviet Union*, Vols. I and II, available from SRI International, 1611 N. Kent, Arlington, Virginia 22209.

## PROJECT: Scientific and Technological Education and Personnel in the Soviet Union

**Objective:**

To examine and evaluate the education and utilization of scientists, engineers, and technicians in the Soviet Union.

**Method:**

Quantitative and qualitative assessments will be made using a number of rare Soviet sources on education and human resources, many of which have not been utilized by Western

analysts to date. The researchers have an impressive collection of such materials and will augment this collection with additional reports and data, including unpublished statistical and sociological material appearing in Soviet dissertations. The project will also analyze data collected by the U.S.-U.S.S.R. joint working group on science and technology as well as two emigre interview projects on Soviet science and technology. Appropriate comparisons will be made with other industrialized nations, particularly the United States.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Anaytical Studies Section/International Studies Group

**Institution/Principal Investigators:**

Georgetown University/Harley D. Balzer and Murray Feshbach

**Availability:**

A final report is expected in late 1988.

## PROJECT:
## Science and Technology Resources of Japan

**Objective:**

To provide quantitative information on science and technology (S/T) resources and activities in Japan.

**Method:**

S/T data from various sources will be examined, compiled, and analyzed. Japanese national reports, as well as data from the Organisation for Economic Co-operation and Development, will be utilized. Comparisons will be made with data on the United States.

**Major Findings:**

Since the midsixties, Japanese S/T resources have been expanding steadily in all sectors. Japan now spends a larger amount on research and development than any one of the major European countries, and about 40% as much as the United States. Japanese expenditures for nondefense research and development are about half of those of the United States. The Japanese Government funds a smaller proportion of total research and development than other advanced societies. In several Japanese industries, the total amount of corporate-funded research and development is equal to that of the United States. In the early eighties, Japan announced its plan to increase support for fundamental research. Some signs of this shift are the continued expansion of Ministry of Education support for basic research, and the new interest of other ministries and of industry in basic research.

**Responsible SRS Organization:**

Special Analytical Studies Section/International Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

The final report is expected in early 1988 and will be available from SRS/Office of the Division Director.

## PROJECT:
## Science and Technology Resources of the Pacific Rim Countries

**Objective:**

To provide a baseline of science and technology (S/T) indicator data for the Pacific Rim countries of China, South Korea, and Taiwan.

**Method:**

Through library searches and onsite visits, the principal investigators will identify S/T data sources, collect such data, and provide a baseline of statistical data on S/T resources in the Pacific Rim nations of China, South Korea, and Taiwan. They will evaluate the comparability of various surveys, measurements, and indicators, and identify ways in which a set of common S/T related indicators could be developed to aid the United States in better understanding the nature and pace of S/T progress, or lack of it, in these countries.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Anaytical Studies Section (SASS)/International Studies Group

**Institution/Principal Investigators:**

China Consulting Associates/Denis Fred Simon and Richard P. Suttmeier

**Availability:**

Final report is expected to become available by fall 1988.

## PROJECT:
## Science and Technology Resources of West Germany

**Objective:**

To provide quantitative information on science and technology (S/T) resources in West Germany.

**Method:**

S/T data from various sources were examined, compiled, and presented. West German national reports were utilized, as well as data from the Organisation for Economic Co-operation and Development. Comparisons were made with pertinent data on the United States.

**Major Findings:**

Although West German expenditures for research and development are only one-fifth those of the United States, the ratio of these expenditures to the GNP has been similar for each of the two countries since the late seventies. Estimates for 1985 indicate that the United States had increased its R&D/GNP ratio to 2.7% compared with 2.6% in West Germany. West Germany has a higher ratio of nondefense research and development (R&D) expenditures to GNP than does the United States. In 1985, the West German ratio was estimated to be 2.5% compared with 1.9% for the United States.

R&D funding is seen as an important priority for both Governments. West German Federal budget data show a 16% increase for research and development between 1983 and 1985, compared with a 28% increase in the United States. Energy represented a higher proportion (15%) of Government R&D funds in West Germany than in the United States (6%) in 1984. But the West German Federal Government plans to decrease funding in this area through 1987, and estimates for 1985 show that energy had decreased to 13% of total Government R&D spending. In 1983, the West German Federal Government budgeted $36.4 million for research and development in biotechnology, and plans to increase expenditures by about 6% per year through 1987. By comparison, one estimate of U.S. Government expenditures in biotechnology in fiscal years 1982 and 1983 was over $522 million.

There were a number of subfields in 1982 in which West German articles represented at least 10% of the world's S/T literature: Applied chemistry, 15%; nuclear technology, 14%; orthopedics, 13%; obstetrics/gynecology, 13%; microscopy, 12%; metals and metallurgy, materials science, and nuclear and particle physics, each 10%.

West Germany's competitive edge in many technological areas seems to be decreasing. Its share of world exports in many high-technology product groups has declined and Japan has succeeded West Germany as the foreign leader in U.S. patenting activity in most product groups.

**Responsible SRS Organization:**

Special Analytical Studies Section/International Studies Group

**Institution/Principal Investigator:**

[Intramural]

**Availability:**

*The Science and Technology Resources of West Germany: A Comparison with the United States*, Report NSF 86-310, is available from SRS/Office of the Division Director.

## PROJECT:
## Scientists and Engineers in Selected Industrialized Countries

**Objective:**

To assemble 1985-86 data on the number and characteristics of scientists and engineers in France, Japan, the Federal Republic of Germany, and the United Kingdom for comparison with similar data previously assembled for the 1980-81 period.

**Method:**

The Center for International Research will undertake the updating of the baseline data on scientists and engineers in the four industrialized countries with significant new data that became available during the first six months of 1986. These data were generated by major, national-level census or survey operations. For Japan, preliminary 1985 census tabulations, published around June 1986, will be used in the analysis. French labor-force survey data and data from a special survey of qualified personnel also will be included. Germany's 1985 Microcensus (1%, national sample), and the United Kingdom's 1985 labor-force survey will be used.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section/International Studies Group

**Institution/Principal Investigator:**

Center for International Research, U.S. Bureau of the Census/ Ellen Jamison

**Availability:**

The final report is expected in early 1988.

## PROJECT:
## Stock and Employment of Scientists and Engineers in Selected Countries

**Objective:**

To assist NSF in establishing a systematic data base that can be updated periodically on the stock and employment of scientists and engineers in France, West Germany, Japan, and the United Kingdom. Information will be sought on each country's approach to the classification of technicians and computer specialists and on data sources for these occupations.

**Method:**

Foreign census data were used to prepare estimates of the number of scientists and engineers by detailed occupation.

National classifications of scientists and engineers were adjusted to conform to the classification system used by NSF. Differences in data collection and taxonomies were analyzed.

**Major Findings:**

The United States has more nonacademic scientists and engineers than France, West Germany, Japan, and the United Kingdom combined: 2.9 million in the United States, with total numbers in the other countries ranging from 388,000 in France to 940,000 in Japan. Given the larger total population in the United States, a useful comparison is the proportion of scientist and engineers in the labor force. According to this measure, West Germany and the United Kingdom are tied with the United States for first place, and France and Japan are tied for second place. In all five countries, only minimal proportions of scientists and engineers are women, ranging from 3% in Japan to 11% in France and the United Kingdom, but the numbers of women are slowly increasing.

By sector of employment, scientists and engineers are represented throughout the economies of all of these countries, but the largest proportions of scientists are in service industries (including government), while manufacturing industries predominate among employers of engineers.

**Responsible SRS Organization:**

Special Analytical Studies Section/International Studies Group

**Institution/Principal Investigator:**

U.S. Bureau of the Census/Peter Way

**Availability:**

*Scientists and Engineers in Industrialized Countries: A Comparison of Characteristics for France, West Germany, Japan, The United Kingdom, and the United States* is available from the Center for International Research, U.S. Bureau of the Census, Washington, D.C. 20233.

## PROJECT:
## U.S. and Japanese Engineers

**Objective:**

To develop and analyze indicators of the number, quality, and utilization of U.S. and Japanese engineers.

**Method:**

Information on U.S. and Japanese engineers will be compiled and catalogued from existing data sources. These data will be critically evaluated and analyzed. New data on the career paths of comparable cohorts of U.S. and Japanese engineers will be gathered and analyzed for the purpose of adding substantive insights into these indicators. An evaluation of a sample of engineering curricula in the two countries will provide additional information on the training and knowledge base of engineers. Research will be conducted in both the United States and Japan.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section/International Studies Group

**Institution/Principal Investigators:**

Carnegie Mellon University/Henry R. Piehler and Leonard H. Lynn

**Availability:**

Final report is expected to become available by fall 1987.

## PROJECT:
## U.S. Participation in International Science and Engineering Projects

**Objective:**

To provide for the first time, comparative information and indicators regarding U.S. participation in large-scale international science and engineering research projects.

**Method:**

Data will be collected through interviews and through reviews of literature data bases, and documents. The focus of concern will be on research activities, organizational mechanisms, trends in numbers of participants from different countries, expenditures by category, and funding mechanisms.

**Major Findings:**

NA

**Responsible SRS Organization:**

Special Analytical Studies Section/International Studies Group

**Institution/Principal Investigator:**

SRI International/Catherine P. Ailes

**Availability:**

A report is expected in the summer of 1988.

# appendixes

a. principal investigators
b. intramural publications,1977-87
c. extramural publications,1977-87

# appendix a

# principal investigators


| | page |
|---|---|
| Ailes, Catherine P. | 64,67 |
| Alexander, David | 24 |
| Altbach, Phillip | 61 |
| Anderson, Richard D. | 20 |
| Balzer, Harley D. | 65 |
| Barber, Elinor G. | 19 |
| Blair, Larry | 63 |
| Bozeman, Barry | 49 |
| Chakrabarti, Alok K. | 49 |
| Charp, Sylvia | 24 |
| Citro, Constance F. | 6 |
| Coyle, Susan L. | 17 |
| Crow, Michael M. | 49 |
| Darknell, Frank | 45 |
| DauffenBach, Robert C. | 25 |
| Dix, Linda S. | 26,27 |
| Dunn, William | 53 |
| Evenson, Robert E. | 64 |
| Fechter, Alan | 23 |
| Feshbach, Murray | 65 |
| Finn, Michael G. | 63 |
| Gold, Barry | 19 |
| Hansen, John A. | 62 |
| Hodes, Lance | 39 |
| Holzner, Burkart | 53 |
| Irvine, John | 62 |
| Jamison, Ellen | 66 |
| Knight, Kenneth E. | 45 |
| Kuh, Charlotte V. | 8 |
| Lambright, W. Henry | 57 |
| Lynn, Leonard H. | 67 |
| MacDonald, Brian | 26 |
| Martin, Ben | 62 |
| Miller, Jon D. | 57 |
| Morgan, Robert P. | 19 |
| Narin, Francis | 61 |
| Nasatir, David | 45 |
| Piehler, Henry R. | 67 |
| Rogers, Everett M. | 49 |
| Saxonhouse, Gary | 64 |
| Schankerman, Mark | 46 |
| Simon, Denis Fred | 65 |
| Stephan, Paula | 23 |
| Suttmeier, Richard P. | 65 |
| Teece, David J. | 53 |
| Teich, Albert H. | 19 |
| Terleckyj, Nestor | 36 |
| Walsh, Thomas | 57 |
| Way, Peter | 67 |
| Zdep, Stanley M. | 46 |
| Zinberg, Dorothy S. | 63 |

# appendix b

# intramural publications, 1977-87

## overviews

| | NSF Number | | |
|---|---|---|---|
| | Highlights/ RDSR[1] | Tables | Full Report |
| Academic Science/Engineering: R&D Funds, Federal Support, Scientists and Engineers, Graduate Enrollment and Support | | | |
| 1972-83 | ----- | ----- | 84-322 |
| Academic Science: R&D Funds, Scientists and Engineers, Graduate Enrollment and Support | | | |
| 1972-81 | ----- | ----- | 81-326 |
| 1972-77 | ----- | ----- | 80-313 |
| Comparison of Scientific and Technical Personnel Trends in the United States, France, West Germany, and the United Kingdom Since 1970 | ----- | ----- | 84-335 |
| A Guide to NSF Science/Engineering Resources Data | ----- | ----- | 87-308 |
| | ----- | ----- | 84-301 |
| A Guide to NSF Science Resources Data: 1980 | ----- | ----- | Unnum. |
| International Science and Technology Data Update | | | |
| 1986 | ----- | ----- | 86-307 |
| January 1984 | ----- | ----- | Unnum. |
| January 1983 | ----- | ----- | Unnum. |
| National Patterns of R&D Resources: Funds & Manpower in the United States | | | |
| 1953-77 | ----- | ----- | 77-310 |
| 1953-76 | ----- | ----- | 76-310 |
| National Patterns of R&D Resources: Funds & Personnel in the United States | | | |
| 1953-78-79 | ----- | ----- | 78-313 |
| National Patterns of Science and Technology Resources | | | |
| 1987 | 87-303 | ----- | |
| 1986 | 85-331 | ----- | 86-309 |
| 1985 | 85-304 | ----- | ----- |
| 1984 | 83-316 | ----- | 84-311 |
| 1983 | 82-311 | ----- | ----- |
| 1982 | 81-314 | ----- | 82-319 |
| 1981 | 80-310 | ----- | 81-311 |
| 1980 | 79-309 | ----- | 80-308 |
| Profiles—Chemistry: Human Resources and Funding | ----- | ----- | 87-307 |
| Profiles—Mechanical Engineering: Human Resources and Funding | ----- | ----- | 87-309 |
| Project Summaries | | | |
| Fiscal Year 1986 | ----- | ----- | 86-313 |
| Fiscal Year 1985 | ----- | ----- | 85-324 |
| Fiscal Year 1984 | ----- | ----- | 84-334 |
| Fiscal Year 1983 | ----- | ----- | 83-326 |
| 1982 | ----- | ----- | 82-327 |
| 1980-81 | ----- | ----- | 81-328 |
| Resources Supporting Scientific and Engineering Activities at Historically Black Colleges and Universities | ----- | ----- | 84-332 |
| Science and Engineering Personnel: A National Overview | ----- | ----- | 85-302 |
| | ----- | ----- | 82-318 |
| | ----- | ----- | 80-316 |
| Science Indicators[2] | | | |
| The 1985 Report | ----- | ----- | NSB 85-1 |
| 1982 | ----- | ----- | NSB 83-1 |
| 1980 | ----- | ----- | NSB 81-1 |
| 1978 | ----- | ----- | NSB 79-1 |
| 1976 | ----- | ----- | NSB 78-1 |

[1] *Reviews of Data on Science Resources.*

[2] Prepared for the National Science Board.

| | NSF Number | | |
|---|---|---|---|
| | Highlights/ RDSR[1] | Tables | Full Report |
| Science and Technology Data Book | ----- | ----- | 86-311 |
| | ----- | ----- | 85-323 |
| | ----- | ----- | 84-331 |
| | ----- | ----- | 83-318 |
| The Science and Technology Resources of West Germany: A Comparison with the United States | ----- | ----- | 86-310 |

# human resources

| | | | |
|---|---|---|---|
| U.S. Scientists and Engineers | | | |
| 1984 | ----- | * | ----- |
| 1982, Volume 2 | 84-319 | 85-307 | ----- |
| 1982, Volume 1 | 84-319 | 84-321 | ----- |
| 1980 | 82-303 | 82-314 | ----- |
| 1978 | 80-305 | 80-304 | ----- |
| 1976 | ----- | 79-305 | ----- |
| **Characteristics** | | | |
| Characteristics of Doctoral Scientists and Engineers in the United States | | | |
| 1987 | 87-301 | | |
| 1985 | ----- | * | ----- |
| 1983 | 85-301 | 85-303 | ----- |
| 1981 | 82-328 | 82-332 | ----- |
| 1979 | 81-312 | 80-323 | ----- |
| 1977 | 78-316 | ----- | 77-309 |
| Characteristics of Experienced Scientists and Engineers | | | |
| 1978 | ----- | 79-322 | ----- |
| 1976 | 77-322 | 78-305 | ----- |
| Characteristics of Recent Science/Engineering Graduates | | | |
| 1984 | 85-334 | * | ----- |
| 1982 | 84-310 | 84-318 | ----- |
| 1980 | 82-320 | 82-313 | ----- |
| Immigrant Scientists and Engineers | | | |
| 1985 | ----- | * | ----- |
| 1982-84 | ----- | 85-326 | ----- |
| The 1982 Postcensal Survey of Scientists and Engineers | ----- | 84-330 | ----- |
| Scientists and Engineers From Abroad | | | |
| 1976-78 | ----- | 80-324 | ----- |
| 1966-75 | 77-305 | ----- | ----- |
| The Stock of Science and Engineering Master's Degree-Holders in the United States | ----- | ----- | 81-302 |
| Women and Minorities in Science and Engineering | ----- | ----- | 86-301 |
| | ----- | ----- | 84-300 |
| | ----- | ----- | 82-302 |
| | ----- | ----- | 77-304 |
| **Education** | | | |
| Academic Science/Engineering: Graduate Enrollment and Support | | | |
| Fall 1985 | 87-306 | * | ----- |
| Fall 1984 | 86-303 | Unnum. | ----- |
| Fall 1983 | 85-313 | 85-300 | ----- |
| Fall 1982 | 84-313 | 84-306 | ----- |
| Fall 1981 | 83-310 | 83-305 | ----- |
| Academic Science: Graduate Enrollment and Support | | | |
| Fall 1980 | 82-306 | 81-330 | ----- |
| Fall 1979 | ----- | 80-321 | ----- |
| Fall 1978 | 79-321 | 79-316 | ----- |
| Academic Science/Engineering: Scientists and Engineers | | | |
| January 1985 | ----- | * | ----- |
| January 1984 | ----- | 85-316 | ----- |
| January 1983 | ----- | 84-309 | ----- |
| January 1982 | ----- | 83-311 | ----- |
| Academic Science: Scientists and Engineers | | | |
| January 1981 | ----- | 82-305 | ----- |
| January 1980 | ----- | 81-307 | ----- |
| January 1979 | ----- | 79-328 | ----- |
| Activities of Science and Engineering Faculty in Universities and 4-Year Colleges | 81-317 | ----- | 81-323 |
| Aptitude Test Scores of Prospective Graduate Students in Science Remained Essentially the Same From 1970 to 1975 | 77-318 | ----- | ----- |
| Foreign Citizens in U.S. Science and Engineering: History, Status, and Outlook | ----- | ----- | 86-305 revised |
| Foreign Participation in U.S. Science and Engineering Higher Education and Labor Markets | ----- | ----- | 81-316 |

[1] *Reviews of Data on Science Resources.*

*For information on availability of these Detailed Statistical Tables, please see pp. xi and xii.

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*For information on availability of these Detailed Statistical Tables, please see pp. xi and xii.

| | NSF Number | | |
|---|---|---|---|
| | Highlights/ RDSR[1] | Tables | Full Report |
| Graduate Science Education: Student Support and Postdoctorals | | | |
| Fall 1977 | 78-307 | 78-315 | ----- |
| Fall 1976 | 77-302 | 77-319 | ----- |
| Fall 1975 | 75-335 | 76-318 | 77-313 |
| Growth in Neuroscience May Be Leveling Off | 83-314 | ----- | ----- |
| No Change in Science and Engineering Student Quality Seen by 60% of Academic Officials: At Least 25% Perceive Improvement | 83-322 | ----- | ----- |
| Participation of Foreign Citizens in U.S. Science and Engineering | ----- | ----- | 85-325 |
| Science and Engineering Degrees: 1950-80. A Source Book | 81-320 | ----- | 82-307 |
| Science and Engineering Doctorates | | | |
| 1960-86 | 87-309 | | ----- |
| 1960-85 | 86-308 | | ----- |
| 1960-84 | ----- | Unnum. | ----- |
| 1960-83 | 84-328 | Unnum. | ----- |
| 1960-82 | 83-330 | 83-328 | ----- |
| 1960-81 | 82-323 | ----- | 83-309 |
| **Employment** | | | |
| **General** | | | |
| Characteristics of Recent Science/Engineering Graduates | | | |
| 1984 | 85-334 | * | ----- |
| 1982 | 84-324 | 84-318 | ----- |
| 1980 | 82-320 | 82-313 | ----- |
| Employment Attributes of Recent Science and Engineering Graduates | 80-311 | ----- | 80-325 |
| Employment Patterns of Recent Entrants into Science and Engineering | 78-310 | ----- | ----- |
| Growth in Science and Engineering Employment Accelerated in 1980 to 1981—But Demand May Have Slackened | 83-300 | ----- | ----- |
| Occupational Mobility of Scientists and Engineers | ----- | ----- | 80-317 |
| Projected Response of the Science, Engineering, and Technical Labor Market to Defense and Nondefense Needs: 1982-87 | 83-307 | ----- | 84-304 |
| Science and Engineering Doctorates | | | |
| 1960-86 | 87-309 | | |
| 1960-85 | 86-308 | * | ----- |
| 1960-84 | ----- | Unnum. | ----- |
| 1960-83 | 84-328 | Unnum. | ----- |
| 1960-82 | 83-330 | 83-328 | ----- |
| 1960-81 | 82-323 | ----- | 83-309 |
| Science and Engineering Employment: 1970-80 | ----- | 81-310 | ----- |
| **Government** | | | |
| Federal Scientific and Technical Personnel | | | |
| 1976, 1977, and 1978 | ----- | 81-309 | ----- |
| Federal Scientific and Technical Personnel: Numbers and Characteristics | ----- | ----- | 85-312 |
| Federal Scientists and Engineers | | | |
| 1985 | ----- | * | ----- |
| **Industry** | | | |
| Changing Employment Patterns of Scientists, Engineers, and Technicians in Private Industry: 1977-80 | ----- | ----- | 82-331 |
| Labor Markets for New Science and Engineering Graduates in Private Industry | 84-303 | ----- | ----- |
| | 82-310 | ----- | ----- |
| | 82-330 | ----- | ----- |
| Scientific and Technical Personnel in Private Industry | | | |
| 1978-80 | ----- | 80-320 | ----- |
| 1975 | 78-302 | ----- | ----- |
| 1970 | 77-312 | ----- | ----- |
| Scientists, Engineers, and Technicians in Manufacturing Industries | | | |
| 1985 | 85-330 | * | ----- |
| 1983 | ----- | 85-328 | ----- |
| 1977 | 79-307 | 80-306 | ----- |
| Scientists, Engineers, and Technicians in Manufacturing and Nonmanufacturing Industries: | | | |
| 1980-81 | 83-303 | 83-324 | ----- |
| | 83-321 | ----- | ----- |
| Scientists, Engineers, and Technicians in Nonmanufacturing Industries | | | |
| 1984 | ----- | Unnum. | ----- |
| Scientists, Engineers, and Technicians in Private Industry | | | |
| 1985 | 85-336 | * | ----- |

[1] *Reviews of Data on Science Resources.*

*For information on availability of these Detailed Statistical Tables, please see pp. xi and xii.

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| | NSF Number | | |
|---|---|---|---|
| | Highlights/ RDSR[1] | Tables | Full Report |
| 1984 | 85-309 | ----- | ----- |
| 1980 | ----- | 81-329 | ----- |
| Scientists, Engineers, and Technicians in Trade and Regulated Industries: 1982 | ----- | ----- | 84-320 |
| | ----- | ----- | 84-323 |
| Utilization of Science and Engineering Doctorates in Industrial Research and Development | 78-301 | ----- | ----- |
| **Universities and Colleges** | | | |
| Academic Science/Engineering: Scientists and Engineers | | | |
| January 1985 | ----- | * | ----- |
| January 1984 | 85-317 | 85-316 | ----- |
| January 1983 | 84-317 | 84-309 | ----- |
| January 1982 | 83-317 | 83-311 | ----- |
| Academic Science: Scientists and Engineers | | | |
| January 1981 | 82-312 | 82-305 | ----- |
| January 1980 | 81-315 | 81-307 | ----- |
| January 1979 | 80-309 | 79-328 | ----- |
| Employment Patterns of Academic Scientists and Engineers: 1973-78 | ----- | ----- | 80-314 |
| Engineering Colleges Report 10% of Faculty Positions Vacant in Fall 1980 | 81-322 | ----- | ----- |
| Foreign Citizens in U.S. Science and Engineering: History, Status, and Outlook | ----- | ----- | 86-305 revised |
| Foreign Participation in U.S. Science and Engineering Higher Education and Labor Markets | ----- | ----- | 81-316 |
| Hiring of Science and Engineering Faculty by 2- and 4-Year Colleges | 78-309 | ----- | ----- |
| Human Resources for Scientific Activities at Universities and Colleges | | | |
| January 1978 | 79-315 | 78-318 | ----- |
| Manpower Resources for Scientific Activities at Universities and Colleges | | | |
| January 1977 | 77-327 | 77-321 | ----- |
| Participation of Foreign Citizens in U.S. Science and Engineering | ----- | ----- | 85-315 |
| Tenure Practices in Universities and 4-Year Colleges Affect Faculty Turnover | 81-300 | ----- | ----- |
| Young and Senior Science and Engineering Faculty | | | |
| 1980 | 81-318 | ----- | 81-319 |
| 1978 | 79-301 | ----- | ----- |
| **Projections** | | | |
| Current and Future Utilization of Scientific and Technical Personnel in Energy-Related Activities | 77-315 | ----- | ----- |
| Projected Response of the Science, Engineering, and Technical Labor Market to Defense and Nondefense Needs: 1982-87 | 83-307 | ----- | 84-304 |
| Projections of Science and Engineering Doctorate Supply and Utilization | | | |
| 1982 and 1987 | ----- | ----- | 79-303 |
| **Scientists and Engineers from Abroad** | | | |
| Foreign Citizens in U.S. Science and Engineering: History, Status, and Outlook | ----- | ----- | 86-305 revised |
| Foreign Participation in U.S. Science and Engineering Higher Education and Labor Markets | ----- | ----- | 81-316 |
| Immigrant Scientists and Engineers | | | |
| 1985 | ----- | * | ----- |
| 1982-84 | ----- | 85-326 | ----- |
| Participation of Foreign Citizens in U.S. Science and Engineering | ----- | ----- | 85-315 |
| Scientists and Engineers From Abroad | | | |
| 1976-78 | ----- | 80-324 | ----- |
| 1966-75 | 77-305 | ----- | ----- |
| **Women and Minorities** | | | |
| Women and Minorities in Science and Engineering | ----- | ----- | 86-301 |
| | ----- | ----- | 84-300 |
| | ----- | ----- | 82-302 |
| | ----- | ----- | 77-304 |

[1]*Reviews of Data on Science Resources.*

*For information on availability of these Detailed Statistical Tables, please see pp. xi and xii.

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# financial resources

| | NSF Number | | |
|---|---|---|---|
| | Highlights/ RDSR[1] | Tables | Full Report |
| **Federal Government** | | | |
| An Analysis of Federal R&D Funding by Function | | | |
| FY 1969-79 | 78-317 | ----- | 78-320 |
| FY 1969-78 | 77-320 | ----- | 77-326 |
| FY 1969-77 | 76-319 | ----- | 76-325 |
| Federal Funds for Research and Development | | | |
| FY 1985, 1986, and 1987, Volume XXXV | ----- | * | ----- |
| FY 1984, 1985, and 1986, Volume XXXIV | ----- | Unnum. | ----- |
| FY 1983, 1984, and 1985, Volume XXXIII | ----- | 84-336 | ----- |
| FY 1982, 1983, and 1984, Volume XXXII | 84-302 | 83-319 | 84-326 |
| FY 1981, 1982, and 1983, Volume XXXI | 82-329 | 82-326 | 83-320 |
| FY 1980, 1981, and 1982, Volume XXX | 81-321 | 81-325 | 82-321 |
| FY 1979, 1980, and 1981, Volume XXIX | 80-322 | 80-318 | 81-306 |
| FY 1978, 1979, and 1980, Volume XXVIII | 79-319 | 79-318 | 80-315 |
| FY 1977, 1978, and 1979, Volume XXVII | 79-300 | 78-312 | 79-310 |
| Federal Funds for Research, Development, and Other Scientific Activities | | | |
| FY 1976, 1977, and 1978, Volume XXVI | 77-323 | 77-317 | 78-300 |
| FY 1975, 1976, and 1977, Volume XXV | 76-317 | 76-315 | 77-301 |
| Federal R&D Funding by Budget Function | | | |
| FY 1986-88 | ----- | ----- | 87-305 |
| FY 1985-87 | 86-312 | ----- | 86-306 |
| FY 1984-86 | 85-322 | ----- | 85-319 |
| FY 1983-85 | 84-333 | ----- | 84-316 |
| FY 1982-84 | 83-323 | ----- | Unnum. |
| FY 1981-83 | 82-322 | ----- | Unnum. |
| FY 1980-82 | 81-321 | ----- | Unnum. |
| FY 1979-81 | 80-319 | ----- | Unnum. |
| FY 1978-80 | 79-314 | ----- | Unnum. |
| Federal R&D Funding for Energy: Fiscal Years 1971-84 | ----- | ----- | 83-301 |
| Growth in Federal Basic Research Support in 1980-83 Moves at Slower Rate Than in Previous Four Years | 82-325 | ----- | ----- |
| **Industry** | | | |
| Biotechnology Research and Development Activities in Industry: 1984 and 1985 | 87-304 | ----- | 87-311 |
| A Comparative Analysis of Information on National Industrial R&D Expenditures | ----- | ----- | 85-311 |
| A Comparison of National Industrial R&D Estimates With Actual NSF/Census Data | 78-303 | ----- | ----- |
| Companies Plan Increases in R&D Spending Through 1984 | 83-327 | ----- | ----- |
| Companies Plan R&D Expenditure Increases for 1983: Growth Rate Down | 82-324 | ----- | ----- |
| Company-funded Research and Development Expected to Increase 5% in 1987 | 86-314 | ----- | ----- |
| Dollar Value of U.S. Expenditures Overseas Declined in 1982 | 83-329 | ----- | ----- |
| Plans for Company-Funded Research and Development Show 12% Annual Increases Through 1985 | 84-329 | ----- | ----- |
| Problems of Small, High Technology Firms | ----- | ----- | 81-305 |
| Research and Development in Industry | | | |
| 1984 | ----- | Unnum. | ----- |
| 1983 | 85-318 | 85-325 | ----- |
| 1982 | 84-314 | 84-325 | ----- |
| 1981 | 83-313 | 83-325 | ----- |
| 1980 | 81-331 | 82-317 | ----- |
| 1979 | 81-313 | 81-324 | 82-304 |
| 1978 | 80-300 | 80-307 | ----- |
| 1977 | 79-302 | 79-313 | 79-325 |
| 1976 | 78-306 | 78-314 | ----- |
| 1975 | 76-324 | ----- | 77-324 |
| Trends to 1982 in Industrial Basic Research | ----- | ----- | 83-302 |
| Trends in Small Companies' R&D Expenditures | ----- | ----- | 84-324 |

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| | NSF Number | | |
|---|---|---|---|
| | Highlights/ RDSR[1] | Tables | Full Report |
| U.S. Industrial R&D Spending Abroad | 79-304 | ----- | ----- |
| **Universities and Colleges** | | | |
| Academic Science/Engineering: R&D Funds | | | |
| FY 1985 | 87-305 | * | ----- |
| FY 1984 | 86-302 | Unnum. | ----- |
| FY 1983 | 85-306 | 85-308 | ----- |
| FY 1982 | 84-307 | 84-308 | ----- |
| FY 1981 | 83-304 | 83-308 | ----- |
| Academic Science: R&D Funds | | | |
| FY 1980 | 82-309 | 82-300 | ----- |
| FY 1979 | 81-304 | 81-301 | ----- |
| FY 1978 | 80-301 | 79-320 | ----- |
| Expenditures for Scientific Activities at Universities and Colleges | | | |
| FY 1977 | 78-319 | 78-311 | ----- |
| FY 1976 | 77-314 | 77-316 | ----- |
| FY 1975 | 76-307 | 76-326 | 77-307 |
| Federal Support to Universities, Colleges, and Selected Nonprofit Institutions | | | |
| FY 1985 | ----- | * | ----- |
| FY 1984 | ----- | Unnum. | ----- |
| FY 1983 | 85-314 | ----- | 85-321 |
| FY 1982 | 84-305 | ----- | 84-315 |
| FY 1981 | 83-306 | ----- | 83-325 |
| FY 1980 | 82-301 | ----- | 82-308 |
| FY 1979 | 81-303 | ----- | 81-308 |
| FY 1978 | 80-303 | ----- | 80-312 |
| FY 1977 | 79-312 | 79-311 | 79-317 |
| FY 1976 | 78-308 | 77-325 | ----- |
| FY 1975 | 76-327 | 77-303 | 77-311 |
| 1983 Plant Biology Research Expenditures Totaled $200 Million and Were Concentrated in Land-grant Institutions | 84-327 | ----- | ----- |
| One-fourth of Academic Research Equipment Classified Obsolete | 84-312 | ----- | ----- |
| Universities Report Research Equipment Shortages Are Most Severe in the Physical Sciences and Engineering | 85-320 | ----- | ----- |
| **Other** | | | |
| R&D Funding Projections 1990 | ----- | ----- | 82-315 |
| Research and Development in State and Local Governments | 80-302 | 79-327 | ----- |

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*For information on availability of these Detailed Statistical Tables, please see pp. xi and xii.

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# appendix c

# extramural publications, 1977-87

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